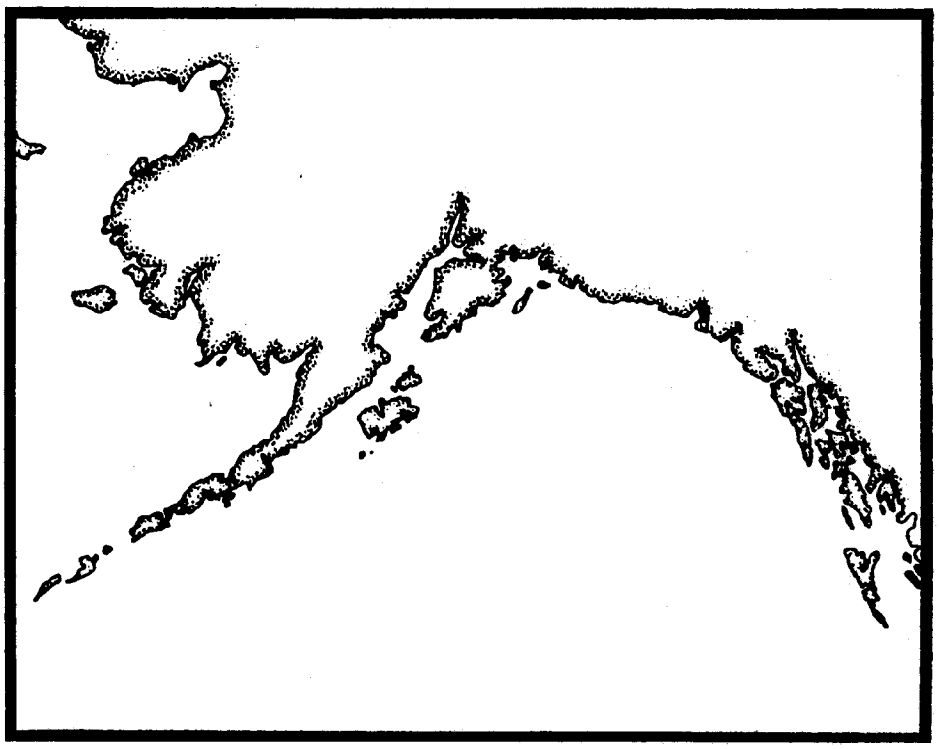
18063

NOAA Technical Memorandum NMFS F/NWC-10

Gulf of Alaska Bottomfish and Shellfish Resources

by
Miles S. Alton

March 1981



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

This document is available to the public through:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

GULF OF ALASKA BOTTOMFISH AND SHELLFISH RESOURCES

by

Miles S. Alton

Resource Assessment and Conservation Engineering Division
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Boulevard East
Seattle, Washington 98112

March 1981

CONTENTS

Figures

Page

Tables

ABSTRACT

The Gulf of Alaska is a part of the northeastern Pacific Ocean that is bordered on the north and east by the state of Alaska. Of the 300 to 400 thousand metric tons of marine animals that are annually harvested from the Gulf, 70% consist of fish and shellfish that live on or near the sea bottom, with most of the remaining harvest consisting of pelagic forms, such as salmon and herring. It is these bottom-dwelling animals that are the subject of this report. They are composed of halibut and other flatfish species; the cod, pollock, sablefish, and other fish species; the pandalid shrimp; and the king, snow (Tanner), and Dungeness crabs. Shrimp and crab are landed exclusively by U.S. nationals. The fishery for Pacific halibut is one of the oldest of the Gulf and now excludes all but U.S. longline vessels. There are small but expanding U.S. fisheries on bottomfish other than Pacific halibut. The foreign trawl and setline fisheries take the bulk of the bottomfish harvested each year, but these fisheries have been subject to strict regulations arising from the passage of the U.S. Fishery Conservation and Management Act (FCMA) of 1976. The Act establishes a fishery conservation zone (FCZ) three miles off the coastal states seaward to 200 miles, under the exclusive fishery management of the United States.

Most of the bottom-dwelling fish and shellfish of commercial importance are on the continental shelf (0-200 m) and upper region of the continental slope (200-500 m). All U.S. fisheries on crab and shrimp, as well as the longline fishery on Pacific halibut, take place in this zone. The foreign trawl fisheries, composed for the most part of vessels from Japan, USSR, and the Republic of Korea (ROK), concentrate their efforts along the outer continental shelf and upper slope (100-500 m), where most of their harvests consist of pollock, Atka mackerel, and flatfish. Along the lower region of the slope from 500 to 1200 m, Japan and the ROK conduct setline fisheries for sablefish. Since 1977, however, these fisheries occur west of long. 140° W because of prohibitions to operating in the FCZ east of that line under FCMA. Since 1979, Japan has been carrying out a longline fishery for Pacific cod in certain areas and seasons in the Gulf of Alaska.

Bottomfish and shellfish of the Gulf of Alaska are discussed in seven faunal categories based on distributional and general life history features. These are 1) the pandalid shrimp that aggregate in mud bottom areas of the shelf and are most plentiful in the bays and nearshore waters of the Kodiak Island region and westward south of the Alaska Peninsula; 2) crabs (king, snow, and Dungeness), rock sole, and sculpins that occur on the continental shelf; 3) Pacific cod and large mouth flounders (Pacific halibut, turbots) that are apex predators in the bottom communities; 4) Dover and rex soles that are strictly benthic feeders in communities living in the soft bottom at the edge of the continental shelf; 5) pollock and flathead sole of outer shelf and upper slope depths; 6) rockfish group, Sebastes spp., that are most abundant in the region of the upper slope (200-500 m) and consist of many species; and 7) bathyal group consisting of sablefish, rattails, rockfish of the genus, Sebastolobus, and species of snow crab that are most abundant in the 400 to 1200 m depth zone of the continental slope.

INTRODUCTION

The Gulf of Alaska contains valuable fish and shellfish resources. In recent years, the annual catches of fish and shellfish from this region have been within the range of 300 to 400 thousand metric tons (t) with an estimated harvest value of more than $200 million. The U.S. fisheries are mainly in Alaskan coastal waters and in the many bays and inlets that border the Gulf where such valuable resources as salmon, crab, and shrimp are caught. Halibut, herring, sablefish, and small amounts of other fish are also taken by U.S. nationals. Of the total amount of fish and shellfish that is caught each year (1976-77), almost half is taken by U.S. nationals. The foreign fisheries, mainly those of Japan, USSR, and the Republic of Korea (ROK), concentrate on the rich bottomfish resources that lie offshore in the deeper waters of the continental shelf and slope.

The purpose of this report is to review our general knowledge of major components of these fishery resources of the Gulf of Alaska--the bottomfish, crab, and shrimp--which amounted to 70% or more of the total annual marine catch of this region in recent years (1976-77). The review covers the fisheries and the biological and distributional features of the major species making up these fisheries. Such a review comes at an appropriate time because of the recently instituted measures to conserve the resources through the Fishery Conservation and Management Act of 1976 (FCMA) and the current interest by U.S. nationals in Gulf of Alaska bottomfish. The Act is aimed not only at rebuilding depleted fishery resources and maintaining levels of stock abundance for optimum yields but also at establishing conditions favorable to the successful development of major U.S. fisheries on bottomfish in the Alaska region. To these ends, catch limits, area-time closures, gear restrictions, and other measures are now in effect in the Gulf of Alaska to prevent overfishing and gear conflicts and to reestablish high levels of abundance for some stocks. In recent years, the annual harvest of bottomfish in the Gulf of Alaska by foreign nationals has fallen from 94% in 1978 to 91% in 1979 (Table 1). This percentage will continue to be reduced as U.S. fishermen increase their catch of bottomfish.

Table 1.--Foreign and domestic harvest of bottomfish from the Gulf of Alaska in 1978-79 (in 1000 metric tons, t).

	1978		1979[1/]	
Fishery	Catch (t)	Percentage	Catch (t)	Percentage
Domestic	9.9	6	15.5	9
Foreign	166.6	94	162.0	91
Total	176.5		177.5	

1/ Preliminary estimates

In this review, only bottomfish and shellfish are considered. Bottomfish are composed of a variety of species ranging from the semidemersal pollock, cod, and Atka mackerel to the more bottom-dwelling flatfish of which Pacific halibut is most familiar (Table 2). Shellfish considered in this review are the commercially valuable crabs (king, snow, and Dungeness) and pandalid shrimp. Data sources for this review are: 1) Japanese fishery statistics that have been provided by Japan to the United States through the International North Pacific Fisheries Commission (INPFC) and compiled in the INPFC Statistical Yearbook; 2) other foreign fisheries statistics available through bilateral agreements with the United States; 3) Pacific halibut catch and effort data given in the Annual Report series of the International Pacific Halibut Commission; 4) U.S. catch data contained in Annual Commercial Fisheries Statistics published by the Alaska Department of Fish and Game; and 5) National Marine Fisheries Service (NMFS) Gulf of Alaska survey results summarized by Ronholt et al. 1978. Other information sources are given elsewhere in this review.

Excluded from the review are pelagic fish (salmon, herring, smelt, and others), squid, and bottom-living mollusks (clams and scallops). For a general treatment of salmon see Salmon Industries of the U.S. (1974). Macy et al. (1978) provided a comprehensive review of the nonsalmonid pelagic fish of the Alaska region. Very little specific information is available on the abundance, distribution, and characteristics of the Gulf of Alaska squid. Nickerson (1975) presented a detailed treatment of the razor clam resource and fishery. Eldridge (1972) discussed the scallops of the Gulf of Alaska.

The metric system is used in this report for depth, weight (of catches), length (of individual fish), and temperature. English units are used with metric equivalents when measurements regarding commercial vessels and gears are discussed and when minimum size regulations are given for individual species. Metric to English conversions can be found in tabular form on the inside of the back cover of this report.

PHYSICAL SETTING

The Gulf of Alaska is bordered by the Alaskan coast from Dixon Entrance to Unimak Pass (Figure 1). This coast is rugged and mountainous and deeply indented by fjords and other inlets of which Chatham Strait, Prince William Sound, and Cook Inlet are notable examples. Glaciers flow down into the heads of some bays. In the northern part of the Gulf of Alaska and south of the Alaska Peninsula are numerous islands of which Kodiak Island is the largest. Major rivers that empty into the Gulf of Alaska are the Copper, Susitna, and Knik.

Table 2.--Principal species of bottomfish, crab, and shrimp of commercial importance and species of minor importance in the Gulf of Alaska.

Group	Subgroup	Common and species name
Bottomfish	Flatfish	Arrowtooth flounder (*Atheresthes stomias*)*
		Dover sole (*Microstomus pacificus*)*
		Flathead sole (*Hippoglossoides elassodon*)
		Greenland turbot (*Reinhardtius hippoglossoides*)
		Pacific halibut (*Hippoglossus stenolepis*)*
		Rex sole (*Glyptocephalus zachirus*)*
		Rock sole (*Lepidopsetta bilineata*)
		Starry flounder (*Platichthys stellatus*)
		Yellowfin sole (*Limanda aspera*)
	Rockfish	Dusky rockfish (*Sebastes ciliatus*)
		Harlequin rockfish (*Sebastes variegatus*)
		Northern rockfish (*Sebastes polyspinis*)*
		Pacific ocean perch (*Sebastes alutus*)*
		Rougheye rockfish (*Sebastes aleutianus*)
		Redstripe rockfish (*Sebastes proriger*)*
		Shortraker rockfish (*Sebastes borealis*)*
		Shortspine thornyhead (*Sebastolobus alascanus*)
	Sculpins	Bigmouth sculpin (*Hemitripterus bolini*)
		Great sculpin (*Myoxocephalus polyacanthocephalus*)
		Red Irish lord (*Hemilepidotus hemilepidotus*)
		Yellow Irish lord (*Hemilepidotus jordani*)
	Cod and cod-like fish	Pacific cod (*Gadus macrocephalus*)*
		Pollock (*Theregra chalcogramma*)*
		Rattails (several species)
	Sablefish	Sablefish (*Anoplopoma fimbria*)*
	Greenlings	Atka mackerel (*Pleurogrammus monopterygius*)*
	Skates	Big skate (*Raja binoculata*)
		Longnose skate (*Raja rhina*)
Crab	King crab	Red king crab (*Paralithodes camtschatica*)*
	Snow (Tanner) crab	Snow (Tanner) crab (*Chionoecetes bairdi*)*
	Dungeness crab	Dungeness crab (*Cancer magister*)*
Shrimp	Pandalid shrimp	Humpy shrimp (*Pandalus goniurus*)
		Pink shrimp (*Pandalus borealis*)*
		Sidestripe shrimp (*Pandalopsis dispar*)

* Principal species of commercial importance

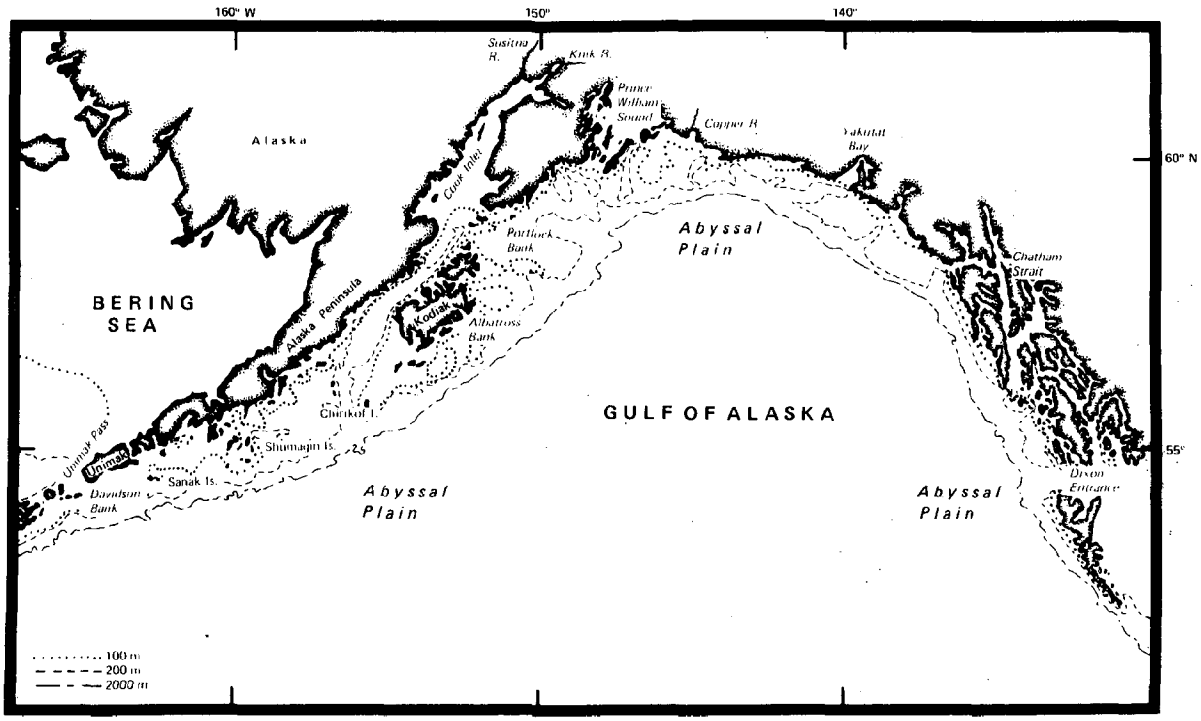


Figure 1.--Gulf of Alaska showing key geographical locations and bathymetry.

The continental shelf reflects the rugged coastline; it is irregular and frequently interrupted by submarine valleys. These deep water valleys or troughs separate broad bank areas such as Albatross and Portlock Banks near Kodiak Island and Davidson Bank south of Unimak Island. In the western Gulf of Alaska, these banks are generally covered with sand and gravel, which indicates the high mobility of the overlying water. In contrast, the sea valleys adjacent to these banks are sediment laden. Rock croppings occasionally occur along the edge of the banks and where the continental shelf meets the deeper water of the slope. A pronounced feature of the western Gulf of Alaska is a greater frequency and expansiveness of plateau-like banks than in the eastern part of the Gulf (Figure 1).

The continental shelf extends from the coast seaward to depths of approximately 200 m, where bottom depths increase rapidly toward the deep water basin or abyssal plain of the Gulf of Alaska. The region of rapidly increasing depth or slope can be subdivided into an upper slope of 200 to 500 m and a lower slope greater than 500 m. The 2000-m line can be considered the depth boundary between the slope and abyssal plain. In general, bottom

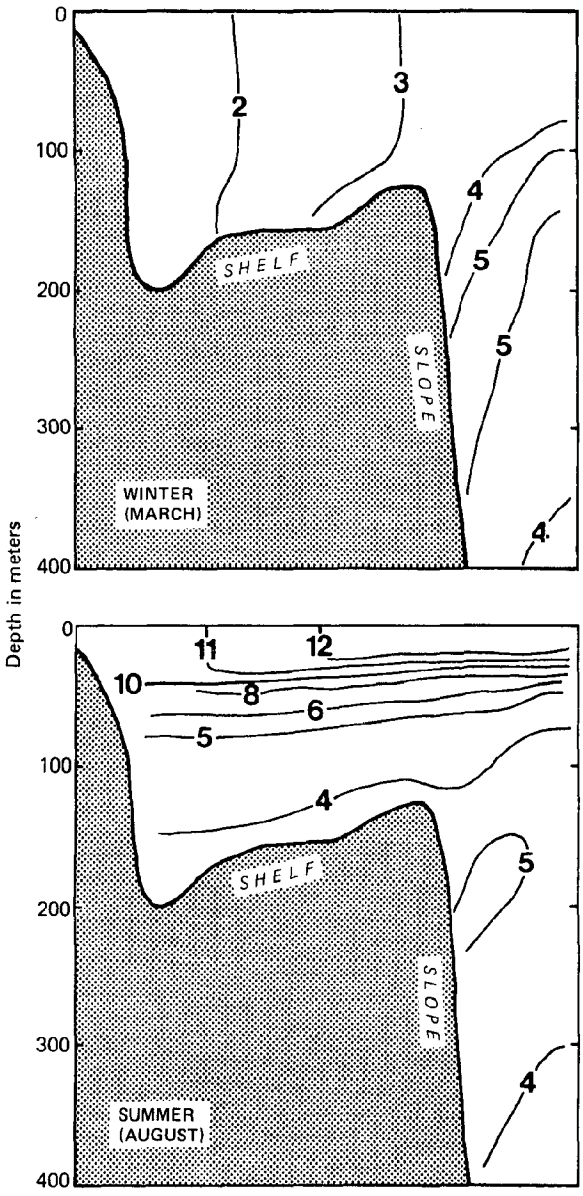


Figure 2.--Typical temperature (degrees Celcius) conditions in a vertical section of water column above the continental shelf and upper slope southeast of Kodiak Island during winter (March) and summer (August). These conditions vary from year to year. (Information for this figure was provided by James Ingraham, Oceanographer, Northwest and Alaska Fisheries Center, Seattle, Wash.).

sediment becomes finer with increasing depth so that in the lower slope and abyssal plain the sediment consists mainly of a mixture of clay and silt. The abyssal plain of the Gulf of Alaska contains submarine mountains that rise thousands of meters from the ocean floor. These are remnants of extinct volcanoes whose upper parts have been eroded away to form flattop seamounts or guyots.

Seaward of the continental shelf, there is a surface flow of water called the Alaska Current which moves in a northwest direction in the eastern Gulf of Alaska and swings to the west and southwest off Kodiak Island and westward toward Unimak Pass. Its rate of flow varies by season and is highest during the winter where, off Kodiak Island, its rate of flow may be 1 knot.

Waters overlying the shelf are subject to the greatest seasonal influences. Winter-induced convection accompanied by turbulence due to storms results in uniform cold temperature in the upper 100 m. It is during the winter that water piles up in coastal waters because of meteorological conditions and brings about a compensating flow seaward along the seabottom. With the shift in wind direction and decrease in wind intensity during the summer, there is surface flow seaward and a compensating transport of water shoreward above the continental shelf. Summer heating and runoff results in a stable temperature and establishment of a thermocline. Temperatures in shelf waters may be as high as 8° to 12°C during the summer but less than 4°C in the winter (Figure 2).

Seasonal effects diminish with increasing depth and distance from shore. Along the outer shelf and upper slope, year-round temperatures of 4° to 5°C persist throughout the periphery of the Gulf of Alaska (Figure 2). With further increase in depth, water temperature shows no significant seasonal change but does decrease, reaching 2°C and less at greater depths.

Most of the commercial fisheries on demersal animal resources take place in the region of the shelf and upper slope. Setline fisheries for blackcod and rattails extend deeper into the lower slope to about 1200 m. No fisheries take place in the abyssal plain or on the seamounts where commercial quantities of fishery resources are believed to be lacking.

Associated with seasonal temperature changes in the bottom water of the shelf are bathymetric shifts in many of the demersal animal populations from shallow to deep during the cooling period and the reverse during the warming period.

FISHERIES

The commercial fisheries on bottomfish and shellfish (crab and shrimp) of the Gulf of Alaska can be placed into three historical periods. The first, from 1867 to the years immediately following World War II, was characterized by the development of the cod, halibut, and sablefish fisheries by North American fishermen. The second period beginning in the 1960's saw the development of the U.S. crab and shrimp fisheries (Figure 3) and the foreign fisheries on bottomfish (Figure 4). The third and current period was ushered in by the Fishery Conservation and Management Act of 1976 which placed all fishery resources within 200 miles of the U.S. coastline under the jurisdiction of the federal government. Annual catches of shellfish and bottomfish by U.S. fishermen for 1960-79 are given in Table 3.

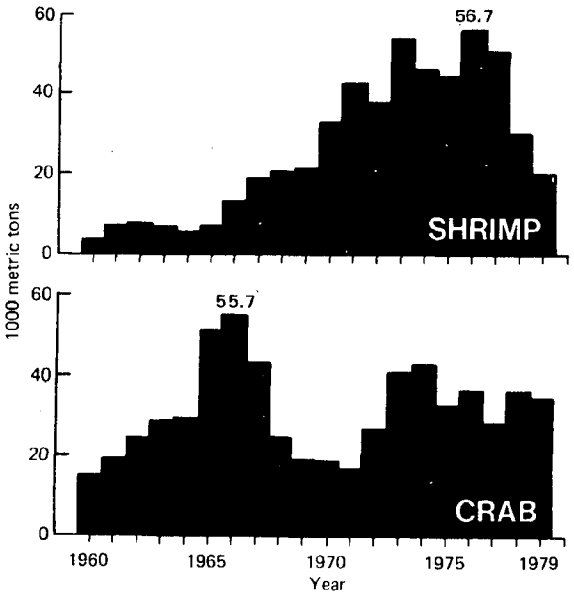


Figure 3.--Domestic harvest of shrimp and crab in the Gulf of Alaska (1960-79).

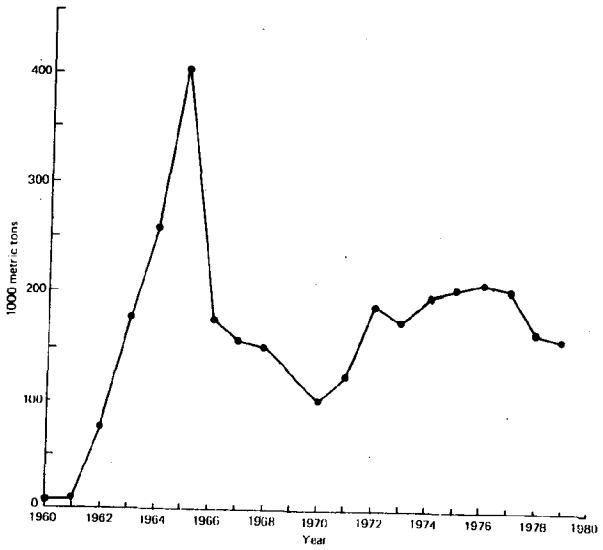


Figure 4.--Annual catch of Gulf of Alaska bottomfish by foreign fisheries (1960-79).

Table 3.--Commercial landings of crab, shrimp, and bottomfish by U.S. vessels operating in the Gulf of Alaska, 1960-79.

Year	Total crab	Total shrimp	Bottomfish		Total bottomfish
			nonhalibut	halibut	
	1000 metric tons				
1960	14.8	3.6	1.4	14.0	15.4
1961	19.9	7.2	0.6	15.3	15.9
1962	24.9	7.7	0.6	15.3	15.9
1963	29.0	7.5	0.7	12.7	13.4
1964	29.5	5.9	0.9	10.5	11.4
1965	47.2	7.3	0.8	12.4	13.2
1966	55.7	13.2	0.8	12.6	13.4
1967	43.4	19.2	0.8	12.2	13.0
1968	25.5	20.4	0.1	7.9	8.0
1969	19.5	21.5	0.2	10.5	10.7
1970	19.1	33.7	0.4	11.3	11.7
1971	16.9	43.0	0.4	9.1	9.5
1972	27.7	38.0	0.8	8.6	9.5
1973	41.6	54.2	1.5	7.5	9.0
1974	43.0	46.7	1.4	5.8	7.3
1975	33.1	44.5	1.4	6.8	8.2
1976	37.6	56.7	1.7	6.5	8.2
1977	28.5	50.9	2.3	5.3	7.6
1978	37.3	30.2	4.5	5.4	9.9
1979[1/]	34.6	20.2	6.8	7.2	14.0

1/ Preliminary and does not include 1,521 t of bottomfish (nonhalibut) taken by U.S. nationals in joint ventures with ROK and USSR in 1979.

The earliest known commercial fishery on bottomfish in the Gulf of Alaska was by U.S. nationals hook-and-line fishing for cod on the banks off the Shumagin Islands beginning in the 1860's. The Shumagin grounds were one of several fishing areas, including those in the Bering Sea, that were fished by U.S. vessels during the heyday of the cod fisheries of Alaska (Cobb 1916, 1927). The cod fishery declined in the 1930's, and since 1941 the annual catch of cod from the Gulf has been small and erratic.

The halibut fishery of the Gulf was a later development than that for cod and had its beginnings after World War I when the fishery expanded its operations from U.S. west coast and British Columbia waters northward. The fishery continues to be important in the Gulf and now involves only U.S. vessels.

The domestic sablefish fishery was relatively unimportant in the Gulf of Alaska fisheries until about 1935 when the annual catch began to rise. After reaching a peak catch of 3,800 t in 1945, the catch of sablefish declined. In current years, the fishery landed less than 1,100 t per year, but favorable market conditions and resource availability brought about a sharp rise to 2,400 t in 1979. Continued growth of the sablefish fishery is predicted

with a possible expansion from the eastern to the western part of the Gulf of Alaska. The domestic harvest of all bottomfish by U.S. nationals reached low levels during 1968-77 due mainly to catch restrictions on Pacific halibut, but a marked rise in the annual catch began in 1978. The importance of bottomfish other than halibut in the domestic fishery has increased in the 1970's; and in 1979, for the first time in decades, the nonhalibut catch exceeded the domestic halibut catch (Figure 5).

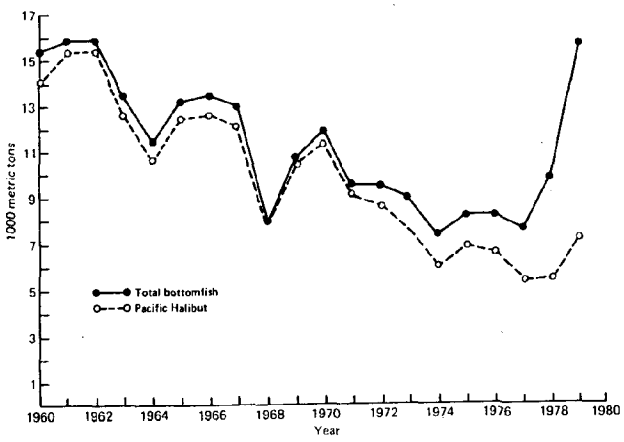


Figure 5.--Annual U.S. harvest of all bottomfish compared to that of Pacific halibut for the Gulf of Alaska.

The high production fisheries for shellfish by U.S. nationals and those for bottomfish by foreign fleets had their beginnings in the late 1950's and early 1960's, reaching peak levels in the 1960's or 1970's. For U.S. fisheries, the year of high production for king crab was 1966 when 53.4 thousand t were caught. The U.S. snow crab fishery had a later start than that of the king crab fishery, reaching maximum catch levels in the 1970's. The Dungeness crab fishery, which is the oldest of the crab fisheries of the Gulf of Alaska, underwent a rapid expansion in the 1960's when annual catches rose to 4,000 to 6,000 t, but annual production has decreased from the peak levels of the mid-1960's. At present it can best be described as a sporadic fishery. Domestic shrimp catches increased rapidly in the early 1960's to levels between 44 and 57 thousand t in 1973-77 and then declined in 1978-79.

The foreign fisheries on Gulf of Alaska bottomfish started in 1962 when a Soviet fleet consisting of 70 trawlers and support vessels began fishing for Pacific ocean perch. The following year a smaller fleet of Japanese vessels entered the Gulf and directed its effort on Pacific ocean perch and sablefish. The Soviet and Japanese fisheries rapidly increased their catches of bottomfish in the 1960's, bringing about declines in the abundance of Pacific ocean perch and other bottomfish stocks. In 1973 and subsequent years, fishing vessels from other nations (Republic of Korea (ROK), Poland, and Taiwan) began fishing for Gulf of Alaska bottomfish.

Currently several distinct fisheries exist in the Gulf of Alaska. For U.S. nationals, there are fisheries exclusively for Dungeness crab, king crab, snow crab, shrimp, and bottomfish, with each fishery having its own set of regulations. There is the traditional halibut fishery involving U.S. and Canadian fishermen. By 1981 this fishery will be conducted only by U.S. nationals.

U.S.-foreign joint ventures are in early stages of growth. In these fisheries, U.S. vessels harvest pollock and other bottomfish and deliver them to foreign processing vessels. Gulf of Alaska fisheries that are conducted exclusively by foreign nationals are the trawl fishery and setline fishery for bottomfish. Each of these can be further subdivided by nation.

Regulations

Fishery Conservation and Management Act of 1976

This Act provided a means by which the vast and important fishery resources in U.S. waters could be protected from overfishing and managed for optimal use. The Act established a 3- to 200-mile fishery conservation zone (FCZ) adjacent to the territorial sea (0-3 miles) and gave the federal government the authority to regulate the fisheries in the FCZ. The major impetus to the passage of FCMA was the inadequacy of control on the foreign fisheries which had, by 1976, drastically reduced the size of some important stocks of bottomfish (Pacific ocean perch, sablefish, and other species) or contributed to the decline of other resources (e.g., Pacific halibut) indirectly through incidental catches.

By this Act, regional fishery management councils (the North Pacific Fishery Management Council has responsibility for waters off Alaska) are charged with developing fishery management plans (FMP) for each fishery in the FCZ, both foreign and domestic. Such FMP's contain a specification of optimum yield (OY) for a given resource which is based on an estimated annual maximum sustainable yield (MSY) but modified according to relevant ecological, economic, and social considerations. For example, the OY of a stock might be set lower than the MSY to allow an increase in the number of larger and more economically valuable fish or to increase stock density to make the resource more economically available. In some cases, the OY of a resource (e.g., flatfish taken in a bottom trawl fishery) would be established below MSY to reduce the amount of a valuable species, such as halibut, taken incidentally in the fishery.

For the Gulf of Alaska, the FMP's[1/] specify regulations that have in common the objectives of: 1) preventing overfishing, 2) rebuilding depleted stocks, 3) noninterference of foreign fisheries in the conduct of U.S. fisheries, and 4) protecting resources (Pacific halibut, herring, salmon) that are fished exclusively by U.S. fishermen. Allowable catches for groundfish in 1979 are listed in Table 4 along with the total catches that were realized that year and the estimated potential yield under optimum conditions. The allowable catches for Pacific ocean perch and sablefish are below current equilibrium yield (Table 4) so that rebuilding of these depleted stocks can be achieved.

Table 4.--Estimated potential yields of Gulf of Alaska bottomfish stocks (excluding Pacific halibut) and actual yields obtained in 1979 by foreign fisheries.

Species or group	Yield under optimum conditions[1/]	Condition of resource[2/]	Yield under current conditions	Allowable yield[4/]	Actual foreign catch
	1000 metric tons				
Pollock	169-338	+	[3/]	168.8	103.2
Cod	34.8-69.1	+	[3/]	34.8	13.2
Flounders	67	+	[3/]	33.5	13.5
Pacific ocean perch	125-150	-	50	25.0	9.7
Other rockfish	7.6-10	+	[3/]	7.6	1.4
Atka mackerel	33	+	[3/]	26.8	10.9
Sablefish	22-25	-	17.4-19.8	13.0	6.9
Other species	?			16.2	4.1

1/ Same as "maximum sustainable yield" (MSY).
2/ +, current conditions allow the stock(s) to be fished at MSY.
-, current conditions do not allow the stocks to be fished at MSY but at a lower level.
3/ Same as MSY.
4/ Yield that conforms to current socioeconomic and ecological demands and current stock conditions.

1/ Fishery Management Plan for Gulf of Alaska Groundfish (bottomfish = groundfish); Fishery Management Plan for Snow Crab off Alaska.

Species that are fully used by U.S. fishermen are designated as "prohibited" and not allowed to be retained by foreign fishermen. These resources include Pacific halibut, herring, salmon, shrimp, scallop, crabs, and coral. When these animals are taken incidentally, they must be immediately returned to the sea.

In addition to catch limitations, foreign fishermen are subject to rules governing the reporting of catches, fishing methods, and where and when fishing can take place. Every foreign fishing vessel must have a valid permit issued by the U.S. Department of Commerce and, if requested, provide accommodations for a U.S. technical observer.

State of Alaska

The State of Alaska has jurisdiction over those domestic fisheries of the Gulf of Alaska which occur in inside waters and the territorial sea (0-3 miles) and for certain aspects of domestic fisheries in offshore waters for which a Council-developed FMP has not yet been implemented (king crab and shrimp fisheries). State management measures vary among fisheries but include guideline harvest levels, closed seasons, area registration, gear limitations, size and sex restrictions (crabs), and limited entry. Details of these regulations and management rationale may be found in the discussion of the individual fisheries.

U.S. Fisheries

Dungeness Crab Fishery

Dungeness crab live in nearshore waters along the open coast and in bays and inlets. Male crabs grow to sizes of 15-18 cm in carapace width, while the females grow to lesser sizes. Crabs are fished principally by using circular-shaped, metal-framed pots that are 3 to 5 ft (0.9-1.5 m) in diameter and 1-1/2 ft (0.4 m) in height and covered with stainless steel wire mesh (Figure 6). The crabs, attracted by the bait inside the pot, enter through one-way tunnels. A 4 to 4-3/8 inch (10-11 cm) diameter ring is provided on top or on each side of the pot to allow most female and undersized male crabs to escape. Pots are set and retrieved from various types of vessels. In the Kodiak Island fishery, Alaska salmon seiners and power barges equipped with live tanks are used to catch crab. Pots are fished mainly at bottom depths of 40 m and less.

The Dungeness crab fishery is regulated by the State of Alaska. Only specified gear (pots, ring nets, or diving gear) is allowed for harvest of crabs. Female crabs and those male crabs less than 6-1/2 inches (16.5 cm) in carapace width may not be retained. Fishing is restricted to specified periods which vary by management area. There are additional restrictions regarding vessel registration, catch reporting, and number of pots allowed per fishing vessel.

Annual catches of Dungeness crab from the Gulf of Alaska reached 4,000 to 6,000 t during the years 1963-70, declined to less than 800 t in 1976-77,

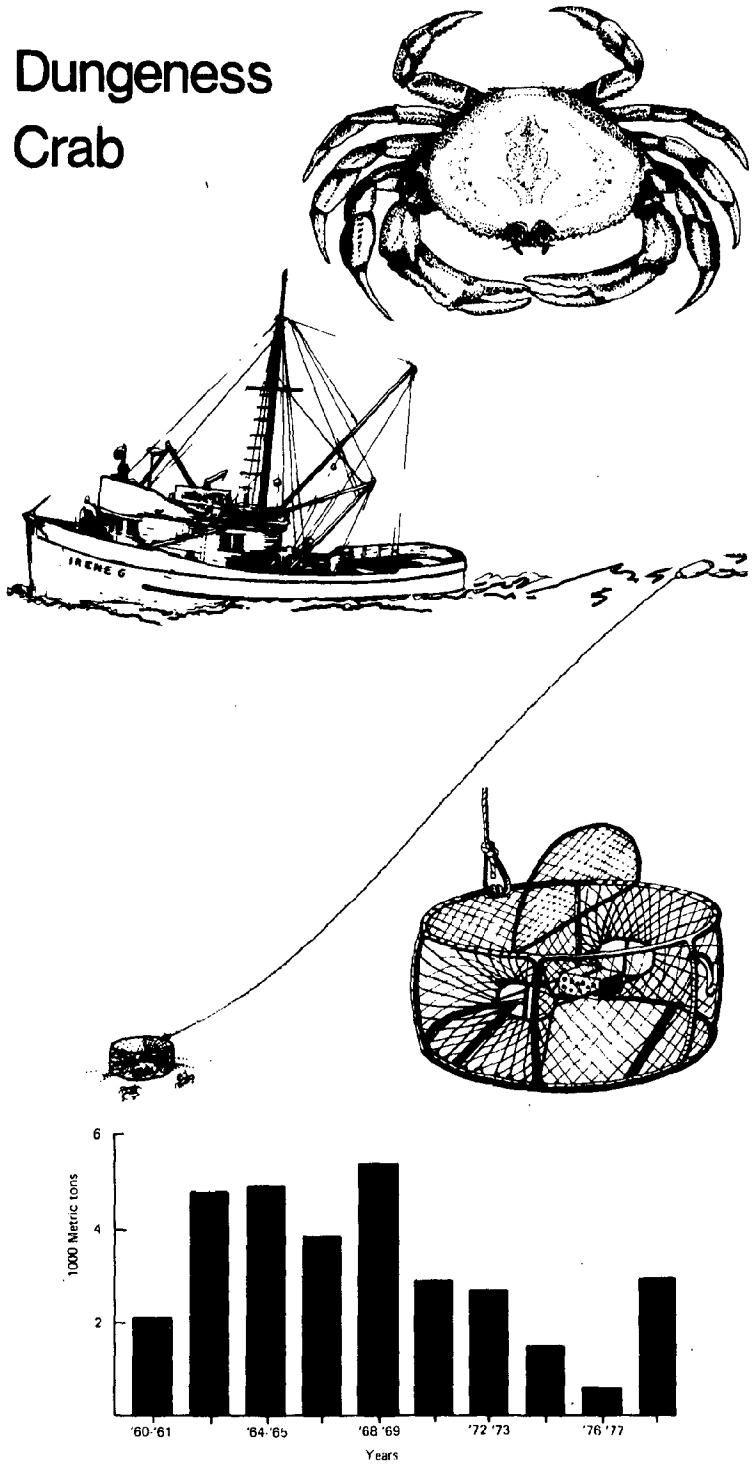


Figure 6.--U.S. annual landings (2-year average) of Dungeness crab in the Gulf of Alaska, showing the principal harvesting method.

and rose sharply to between 2,700 and 3,300 t in 1978-79. Annual catches do not reflect crab abundance change but are related to other factors such as market conditions. Principal fishing regions have been the waters of southeastern Alaska and off Kodiak Island (Figure 7).

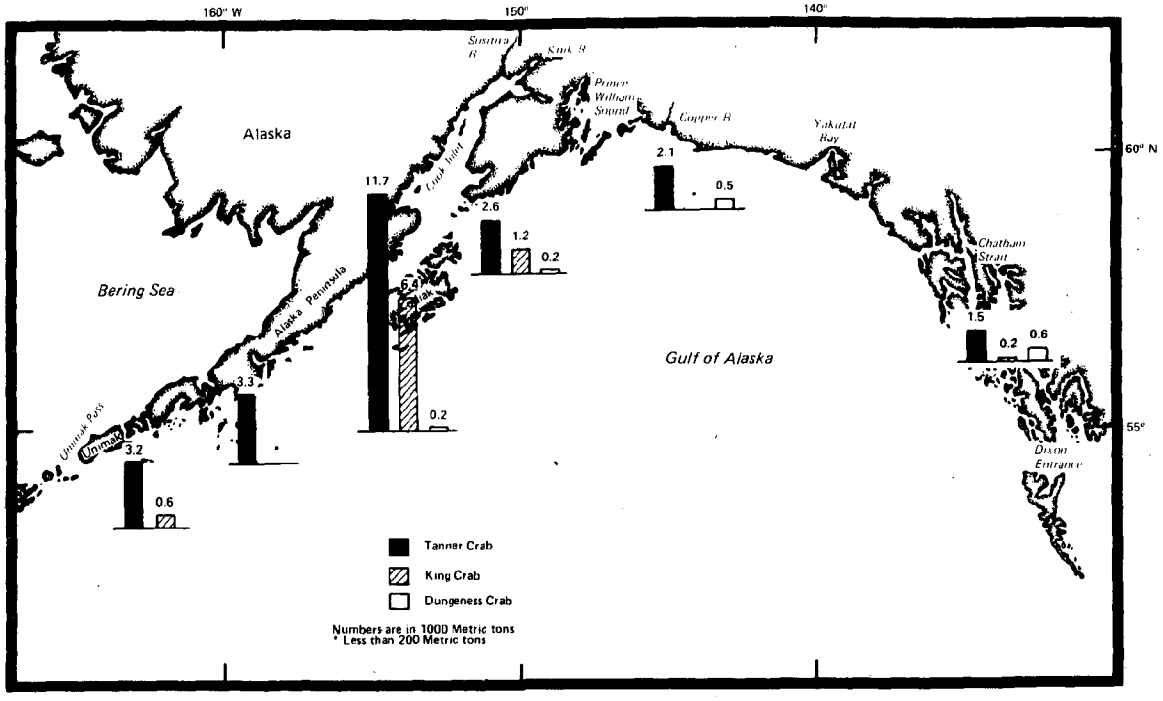


Figure 7.--Average annual U.S. catch of crab by species for 1976-78, by region, in the Gulf of Alaska.

King Crab Fishery

Red king crab is by far the most important of the three king crab species taken in the Gulf of Alaska fishery. Small amounts of the other two species (blue and brown king crab) are taken in the fisheries in southeastern Alaska. Red king crab is fished throughout its range which includes the Gulf of Alaska, Bering Sea, and northwestern Pacific. It is the largest of the king crab species, the males becoming much larger than the females. A male crab may measure 1.5 m across with legs spread and weigh as much as 11 kg. Commercially caught crabs may average 3 kg in weight. They mainly inhabit depths of the continental shelf but may be found deeper, to 400 m. Crabs are caught by means of large, heavy, rectangular-shaped pots (Figure 8) placed on the sea bottom. Attracted by bait, crabs enter through wide openings located on both sides of the pot.

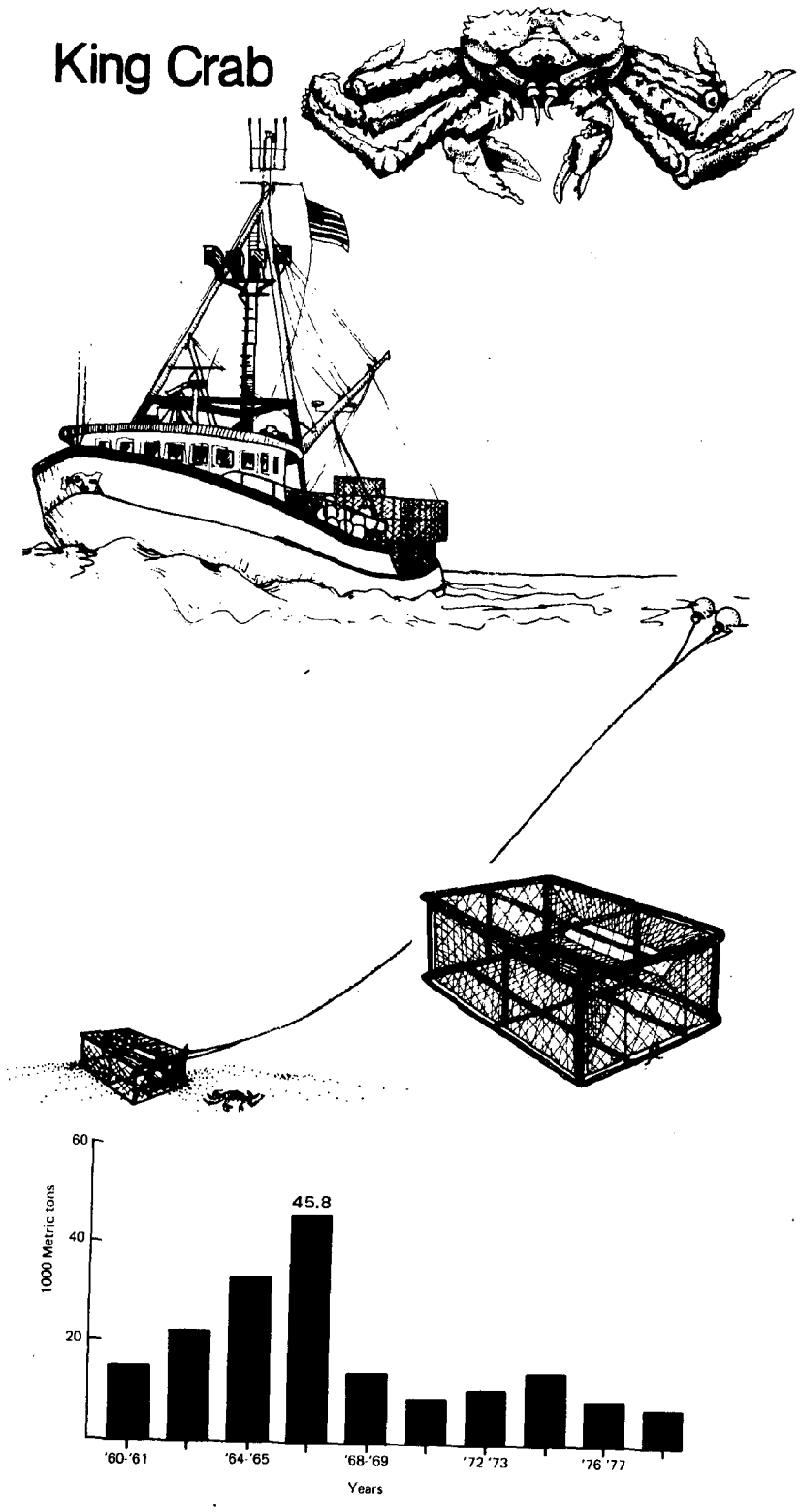


Figure 8.--U.S. annual landings (2-year average) of king crab in the Gulf of Alaska, showing the principal harvesting method.

The Gulf of Alaska king crab fishery is exclusively a U.S. fishery and is regulated by the State of Alaska. Only pots and ring nets may be used depending on area. Regulations are aimed at providing a stable and productive fishery. To ensure adequate reproduction, female crabs may not be taken and harvest levels of males are set to allow a sufficient supply of males for fertilizing the females. One male can provide for several females. To gain stability in the fishery, regulations provide for a broad base of age groups or year classes and hence prevent the fishery from relying on only one or two year classes.

A minimum size limit of 7 in (17.8 cm) is set for king crab, but for certain areas and time periods the size limit might be increased or decreased depending on the condition of the stock. Fishing seasons are usually restricted to the fall-winter period and end when a set harvest level has been reached. There are additional regulations concerning registration, reporting of catches, and number of allowable pots per vessel.

The Gulf of Alaska king crab fishery grew from a small fishery in the 1940's to one in which the annual catch reached levels between 38 and 54 thousand t in the mid-1960's. Since then, the catch has declined and, by 1971-75, average landings were 12.1 thousand t per year. In 1977-79, total landings were less than eight thousand t per year, the lowest since the early years of the fishery. In the Kodiak region where the fishery is centered (Figure 7), the abundance of king crab has been at low levels due to poor recruitment--that is, the number of young crabs reaching commercial size has been below normal in recent years. Recruitment has improved, however, which should be reflected in higher catches in 1980-81.

Snow (Tanner) Crab Fishery

The official trade name for Tanner crab is snow crab although Tanner crab was commonly used in the past. Of the several species of snow crab occurring in the Gulf of Alaska, only one species, Chionoecetes bairdi, is commercially fished for in this region and will be referred to as simply snow crab. As with Dungeness crab and king crab, males grow to a larger size than females. Males may reach sizes of 19.0 cm in carapace width. In the Kodiak fishery, males generally average 15.1-15.5 cm.

The fishery operates on the continental shelf to depths of 400 m. Three basic types of pots used in the Gulf fishery are: 1) a modified version of the king crab pot, 2) a pyramidical pot, and 3) a conical-shaped pot (Figure 9). The tunnel entrances of the king crab pot are reduced in size to accommodate the snow crab which are smaller than the king crab. The pyramidal- and conical-shaped pots are lighter than the king crab pot and can be conveniently stacked when not in use on the deck of the fishing vessel. Vessels engaged in the fishery vary in type and size by region. In southeastern Alaska, Yakutat, Prince William Sound, and Cook Inlet, small seine-type vessels of 32-85 ft (10-26 m) in length dominate the snow crab fishery. To the westward, large modern steel-hulled vessels up to 135 ft (41 m) in length are becoming more important in the fishery off Kodiak and in waters between the Semidi and Shumagin Islands. These large vessels can operate in sea conditions in which smaller vessels cannot be used.

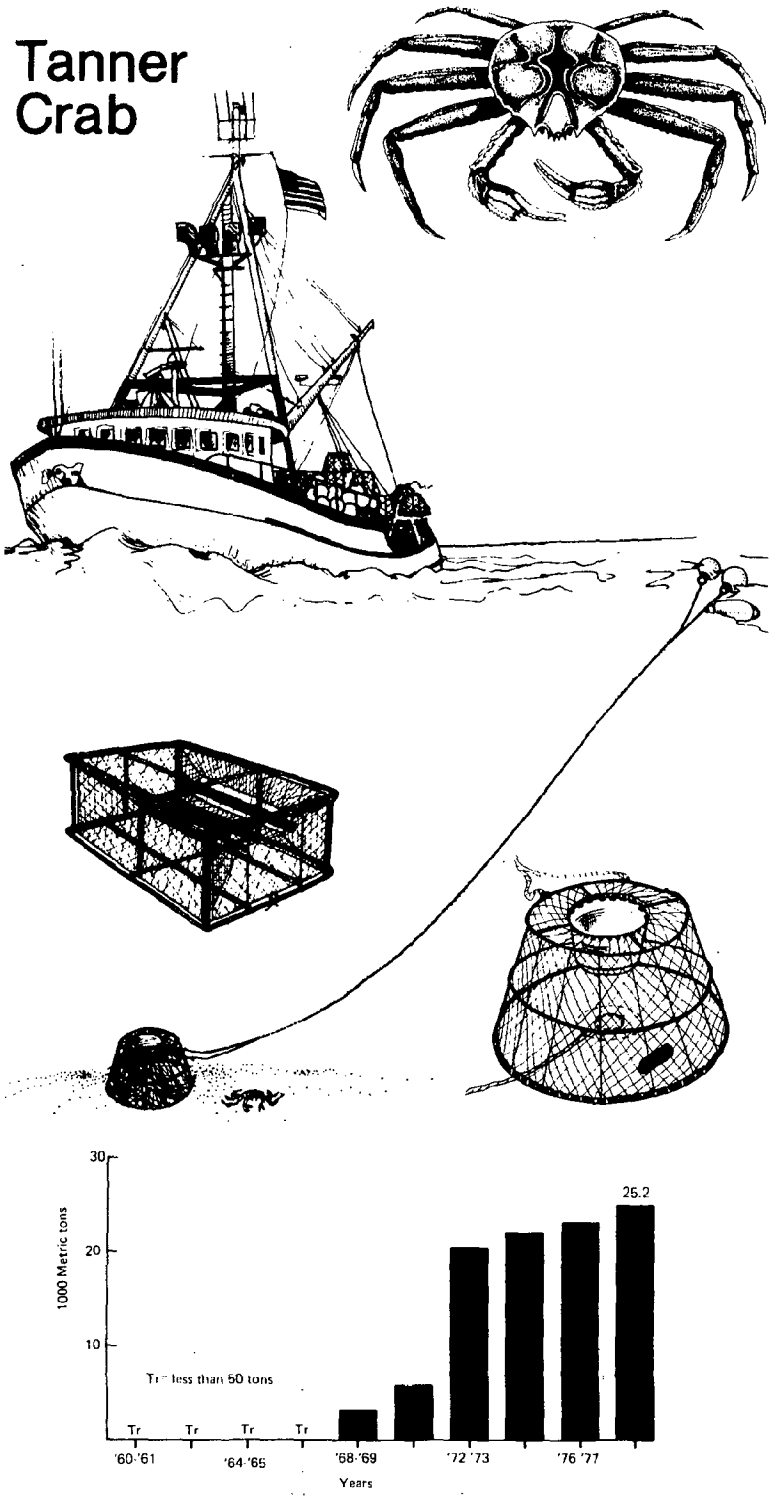


Figure 9.--U.S. annual landings (2-year average) of snow (Tanner) crab in the Gulf of Alaska, showing the principal harvesting method.

The snow crab fishery of the Gulf of Alaska is a recent development. The first significant landings of snow crab (54 t) occurred in 1967, although small catches had been reported as early as 1961. Annual landings of crab rose rapidly after 1967 and, in 1973, a peak catch of 27.6 thousand t was reached. The catches in 1974-78 remained relatively high (18-26.4 thousand t per year). The Kodiak area has been the most important of the fishing areas for snow crab, with annual landings averaging 6.4 thousand t for 1976-78. Lowest producing areas have been those associated with the coastal and inside waters of southeastern Alaska (Figure 7).

The State of Alaska regulates the snow crab fishery of the Gulf of Alaska. Harvest is restricted to males larger than 5.5 in (14.0 cm) in carapace width for all management areas except Prince William Sound, where the limit is 5.3 in (13.5 cm). Fishing is restricted to seasons when meat yield per crab is high and there will be no interference with breeding and hatching of eggs. These seasons vary by management area but are generally confined to the late fall and early spring. A range of harvest levels is also given by the state for each management area based upon an appraisal of what the resource will bear. Additional regulations pertain to the units of gear allowed per vessel, area closures, and reporting of catches.

The snow crab fishery is in a healthy condition. Some areas which have had a history of heavy fishing are closely monitored to prevent resource depletion.

Shrimp Fishery

Commercially fished shrimp of the Gulf of Alaska consist of several species all belonging to the same family, Pandalidae. Pink shrimp is the most important species and makes up at least 85% of the commercial shrimp landings. They are small, and 60 to 160 individuals will weigh only 0.5 kg. Harvest is accomplished principally by means of trawls which are used in pairs from large modern fishing vessels (Figure 10) or singly by smaller vessels. Some beam trawling is also done. Most fishing takes place within 12 miles of the coastline at bottom depths of 50-200 m.

Shrimp fishing is regulated by the State of Alaska. There are area closures and catch limitations to protect the stocks from overharvest. Landing laws are enforced to prohibit the landing and possession of shrimp in closed areas or during closed periods. Trawls and shrimp pots are the only approved methods for harvesting shrimp.

The shrimp fishery of the Gulf of Alaska dates back to 1915, but its full development began in 1958 when a combination of favorable market conditions and improved processing technology (mechanical peeling machines) occurred. Annual landings rose from 3,500 t in 1958 to 20,000 t or more in 1969 and subsequent years. The highest landing on record was 56.7 thousand t in 1976. Shrimp landings declined considerably in 1978-79 (Figure 10).

Shrimp are fished in the southeastern region, Prince William Sound, Cook Inlet, and waters contiguous to Kodiak Island, the Shumagin Islands,

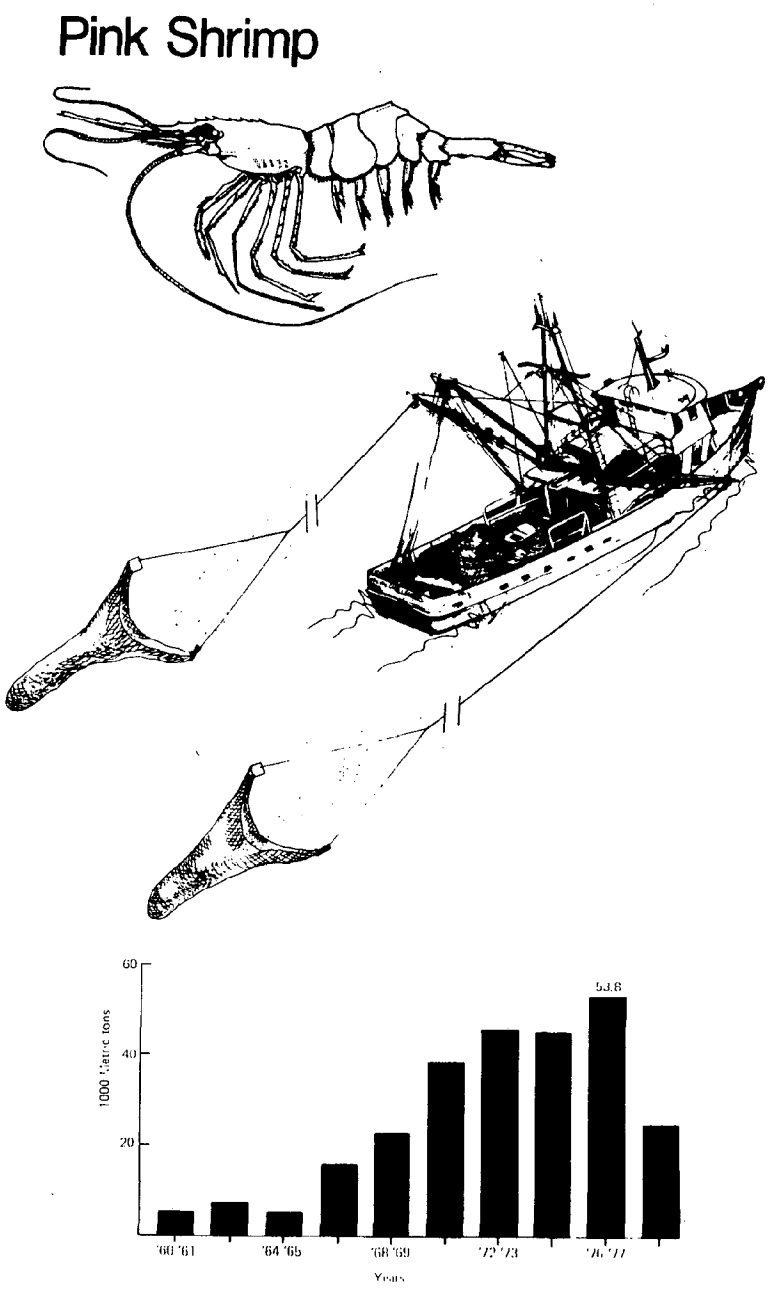


Figure 10.--Annual U.S. landings (2-year average) of shrimp in the Gulf of Alaska, showing the principal harvesting method.

and Unalaska Island. In 1960-71, over 90% of the annual shrimp catch of the Gulf of Alaska came from the Kodiak island area, but in recent years the importance of the Kodiak fishery has diminished as reduced catch quotas have forced fishermen to shift their efforts westward along the Alaska Peninsula. Reduced quotas have been in response to evidence of major declines in the stock abundance in some of the important and traditional fishing areas of the Kodiak region (Alaska Dep. Fish Game 1979). The lowering of the catch quotas in the Kodiak region is an effort by the State of Alaska to protect and rebuild some overfished stocks of that region. To emphasize this shift in fishing effort, the Kodiak catch in 1977 decreased to 14.4 thousand t, while in the same year the catch from waters west of Kodiak Island along the Alaska Peninsula increased to 33.7 thousand t (Figure 11). Since 1977, however, total annual harvest for the Kodiak-Alaska Peninsula region has declined.

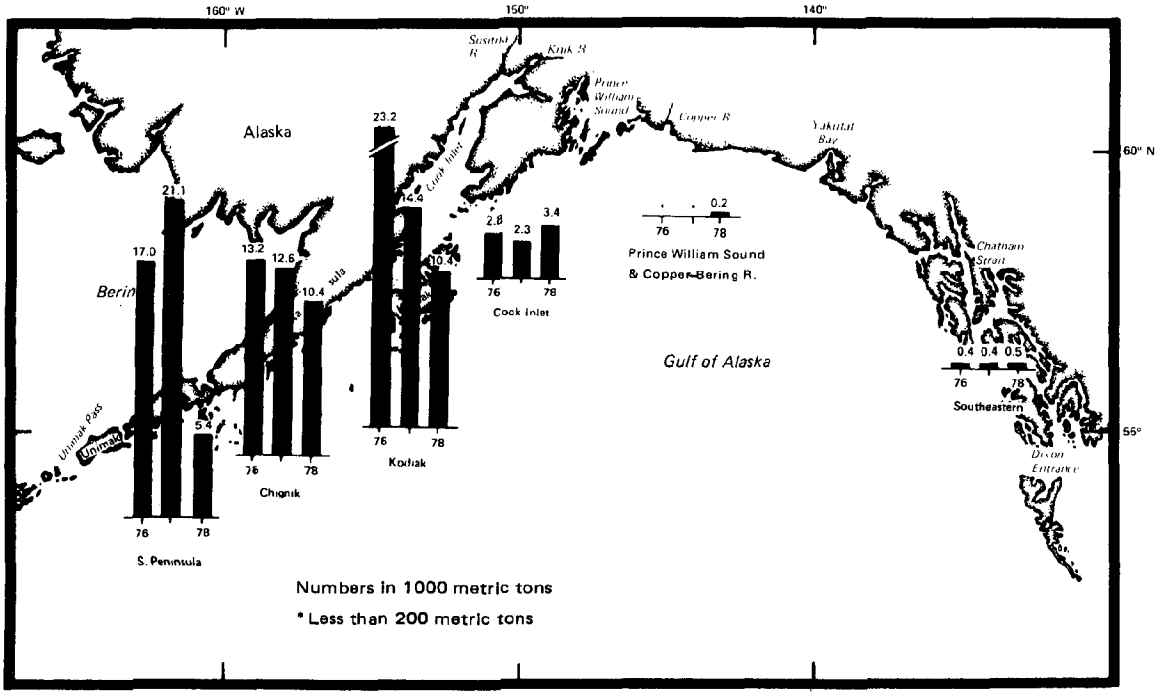


Figure 11.--Regional annual landings of shrimp by U.S. fishermen for 1976-78.

Bottomfish Fisheries

The domestic bottomfish fisheries of the Gulf of Alaska are smaller than the fisheries for crab, shrimp, and halibut. Annual landings of bottomfish, however, increased during the 1970's and reached an all-time high of over 8 thousand t in 1979. The most important of the bottomfish fisheries at this time is that on sablefish. This species occurs in waters off Mexico and California and north to the Bering Sea; its center of abundance is in the Gulf of Alaska. Adult fish inhabit the deep cold bottom waters of bays, straits, fjords, and the slope of the continental shelf. The Alaskan domestic fishery on this species has historically been centered in waters of southeastern Alaska where over 97% of the sablefish of the Gulf of Alaska is harvested. Fishing is by hook and line gear like that used in the North American halibut fishery but with smaller size hooks and shorter spacings between the hooks along the groundline (Figure 12). Trap gear was used extensively during 1971-76 but since 1977 has been replaced almost entirely by longlining. In 1979, the domestic sablefish fleet in southeastern and offshore waters was composed of 200 vessels, most of which were longliners.

Historically, U.S. fishermen were the first commercial harvesters of sablefish in outside waters of southeastern Alaska. Since the early 1940's, the major portion of their sablefish catch came from these waters. From 1967 to 1977, the U.S. Alaskan sablefish fishery was centered in the inside waters of southeastern Alaska, where it became an offseason fishery in the fall for halibut, crab, and salmon. Now, because of increasing markets for sablefish, coupled with catch and season restrictions by the State of Alaska[2/] in the inside waters of southeastern Alaska, the fishery has expanded its operations to offshore waters where a high proportion of the annual catch is now being taken. The expansion has been facilitated by the absence of any interfering foreign setline fisheries in offshore waters. Under authority provided by the FCMA, all foreign setline vessels were prohibited from fishing east of long. 140°W beginning in 1978.

Another domestic bottomfish fishery is that which supplies bait for the crab and halibut fisheries. This fishery occurs from Prince William Sound west to the Aleutians. For many years, the bait catch was taken by fishermen engaged in one of the main fisheries (crab, halibut, or shrimp). In 1979, U.S. trawlers began targeting on bait fish. The annual catch of bottomfish for bait is not known but may range between 500 and 1,500 t.

2/ For some management districts in southeastern Alaska (essentially Clarence Strait), there is a seasonal closure of the sablefish fishery from November 16 to June 14, while for other more productive districts for sablefish (essentially Chatham Strait), there is both a quota restriction (850,000 lb = 386 mt) and a seasonal closure (November 16 to August 31).

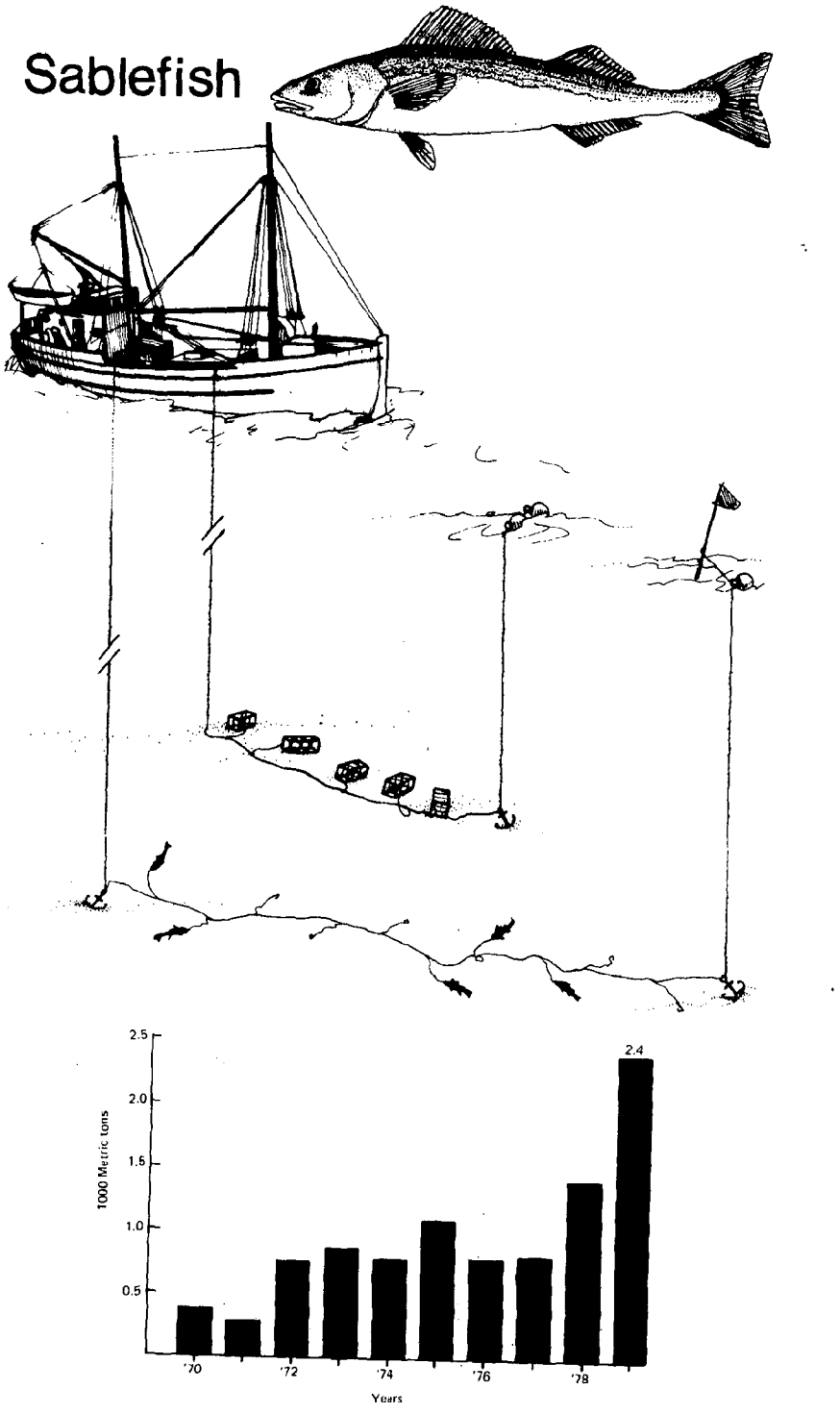


Figure 12.--Annual U.S. landings (2-year average) of sablefish from the Gulf of Alaska, showing the principal methods of harvest.

In 1979, U.S. vessels, engaged in joint ventures with foreign processors, caught 1.5 thousand t of groundfish composed mainly of pollock and cod. Other bottomfish fisheries are often of a regional nature with important ports of landing being Kodiak, Juneau, Petersburg, and Sitka, Alaska. The catch is used for human consumption and fish meal. These fisheries are gradually expanding as market conditions improve and processing capabilities increase.

North American Pacific Halibut Fishery

Pacific halibut is by far the largest of the bottomfish occurring in the Pacific. Individuals may reach a length of over 2 m and a weight exceeding 200 kg; fish of this size are rare, however. Most halibut taken in the fishery weigh between 5 and 100 kg and may average 15 to 20 kg. Females grow to a larger size than males so that most fish greater than 50 kg are females.

Pacific halibut inhabit bottom depths of the continental shelf and slope and are most intensely fished within this region at depths of 25 to 300 m. Only U.S. and Canadian fishermen are engaged in the commercial fishery for this species. Fishing is done from schooners and west coast combination-type vessels using longline gear (Figure 13). This gear consists of a groundline that is laid along the seabottom. Along the groundline at regular intervals are attached lines called gangions with baited hooks. In addition to the commercial fishery for halibut, there is a sport fishery which takes a minor portion of the total halibut landed each year.

The International Pacific Halibut Commission has the authority to recommend regulations for achieving optimum yield to the member governments (U.S. and Canada) on the North American halibut setline fishery and to perform needed research. Present regulations restrict the fishery to a specified period (spring to early fall) and catch level. Furthermore, fishermen may not take or possess a halibut that is less than 81.3 cm in length and may fish only with hook and line. Those engaged in other fisheries, domestic or foreign, are prohibited from taking or retaining any halibut, regardless of size.

Under FCMA, foreign trawl fisheries are not allowed to fish in certain areas of the Gulf of Alaska during certain periods as a means of protecting young or spawning halibut from the foreign fisheries or preventing the interference of these fisheries with the conduct of the North American halibut fishery. Canadian fishermen are being gradually phased out of the halibut fishery in U.S. Gulf of Alaska waters so that by 1981 only U.S. fishermen will be allowed to harvest halibut in these waters.

Annual landings from the Gulf of Alaska by North American fishermen reached an all-time high of 24 thousand t in 1962. High annual catches continued until 1966, followed by a decline; since 1974 the annual catch has been less than 9,000 t. The decrease in stock abundance is believed to be the result of a long-term reduction in the abundance of young halibut brought about by unknown environmental changes but aggravated by the high North

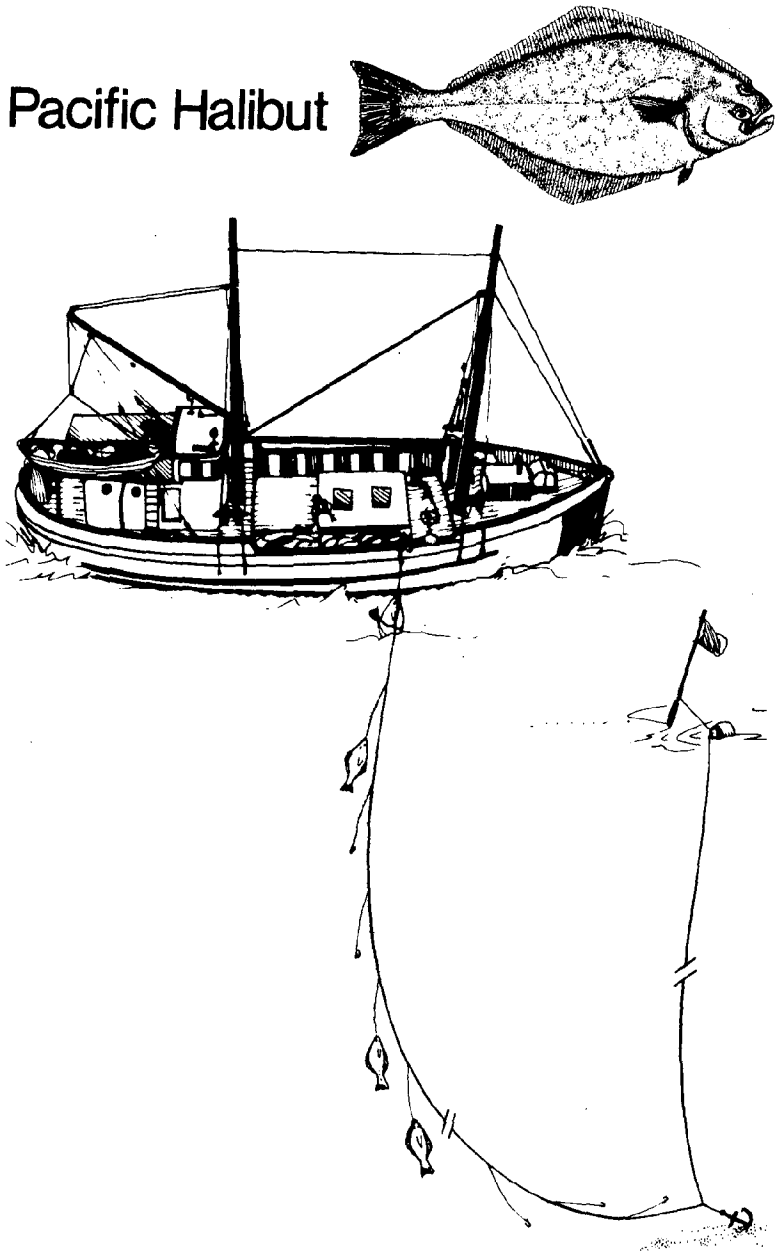


Figure 13.--Canadian and U.S. annual landings (2-year average) of Pacific halibut from the Gulf of Alaska, showing the principal harvesting method.

American catches in the 1960's and the incidental catch of juvenile halibut by the foreign fisheries since 1962. With the imposition of restrictions on the foreign fisheries and a shift towards apparently favorable survival conditions for young halibut, there has been a noticeable increase in the abundance of juvenile fish in recent years--encouraging signs for the future of the stock and the fishery.

The North American halibut fishery operates in both the northeast Pacific and eastern Bering Sea, but 70 to 75% of the annual catch in this fishery comes from the Gulf of Alaska. Halibut are fished throughout the Gulf, with highest production coming from the Kodiak Island area followed by waters of southeastern Alaska (Figure 14).

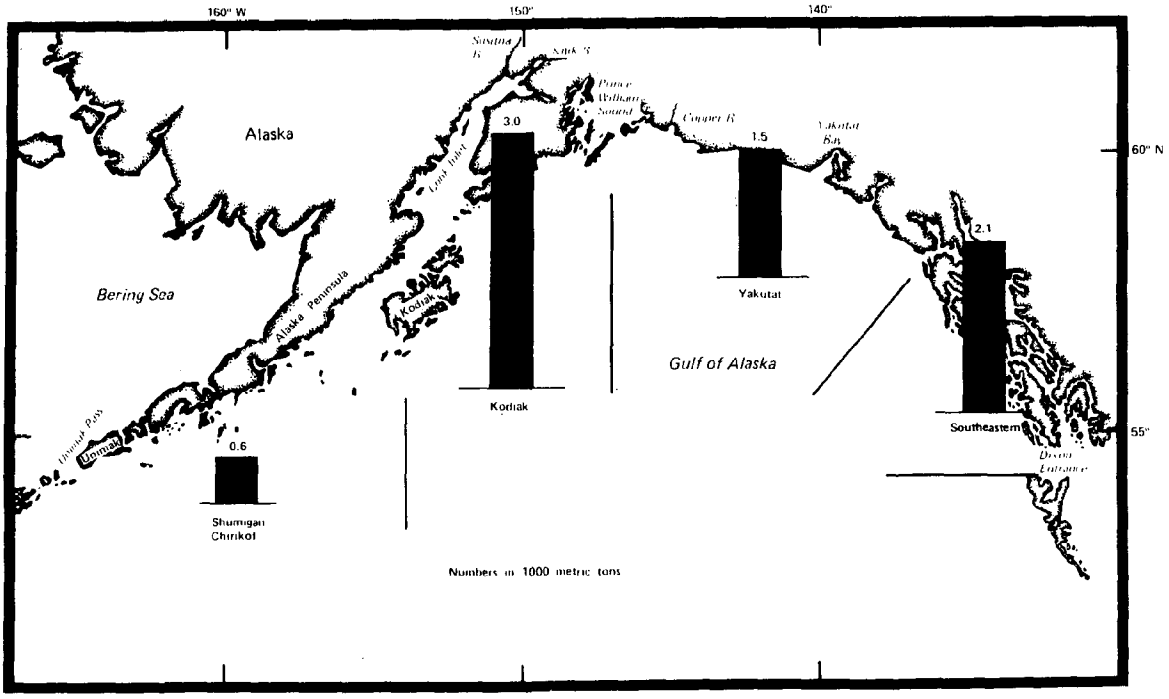


Figure 14.--Average annual catch of Pacific halibut by U.S. and Canadian longline vessels in the Gulf of Alaska by region (1976-78).

Foreign Fisheries

Trawl fisheries

Trawler fleets from Japan, USSR, and ROK have been harvesting a majority of the approximate 200 thousand t of bottomfish that are removed annually from the Gulf of Alaska. Polish and Taiwanese fishermen take a small proportion

of the total catch each year. Bottomfish caught by the foreign trawl fisheries include walleye pollock, Pacific cod, Atka mackerel, sablefish, Pacific ocean perch, other rockfish, and a variety of flatfish. Of these, pollock make up the bulk of the total annual catches (Figure 15). Pollock is a cod-like fish that may reach a length of 70 cm, but most pollock taken by the fisheries fall within the size range of 35 to 55 cm. Pollock are frequently found aggregated at depths of 100 to 400 m along the outer continental shelf and slope and in the deep water straits and embayments that are found in southeastern Alaska and around Kodiak Island. Pacific ocean perch is a spiny-rayed fish that also prefers the near bottom waters of the shelf's edge and slope. Productive fishing areas for perch have been off southeastern Alaska, Yakutat, Kenai Peninsula, and Kodiak Island (Figure 16). Most perch encountered in the fisheries are 25 to 40 cm in length; occasionally fish greater than 45 cm are taken. Of less importance than Pacific ocean perch are other rockfish species which are caught incidentally when the fishing fleets are concentrating on Pacific ocean perch. The foreign trawl fisheries take a relatively small amount of sablefish while targeting on other species. The foreign setline fishery has been the principal harvester of the Gulf of Alaska sablefish.

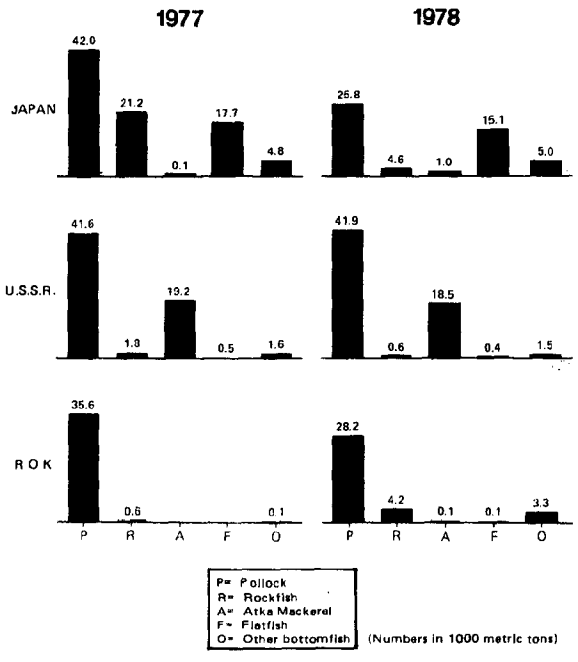


Figure 15.--Catch composition of bottomfish in the foreign trawl fishery in 1977-78 by principal fishing nations.

A third species, Atka mackerel, has become since 1970 an important component of the total catch of all bottomfish. So far, the Soviet fishery has been the only significant harvester of this species, taking an average of 20.6 thousand t per year in 1974-78. Like pollock, Atka mackerel are found in large schools in waters of the outer shelf. The Soviet fishery captures fish that are 25 to 35 cm in length.

Among the flatfish, turbot is the most important in the foreign trawl fisheries, contributing on the average 71% of the total annual catch of all flatfish. Other flatfish that make up a significant part of the flatfish catch are Dover sole, flathead sole, rex sole, and rock sole (Wall et al. 1978).

Both stern trawlers and side trawlers have been used in the foreign trawl fisheries of the Gulf of Alaska, but the role of side trawlers has diminished.

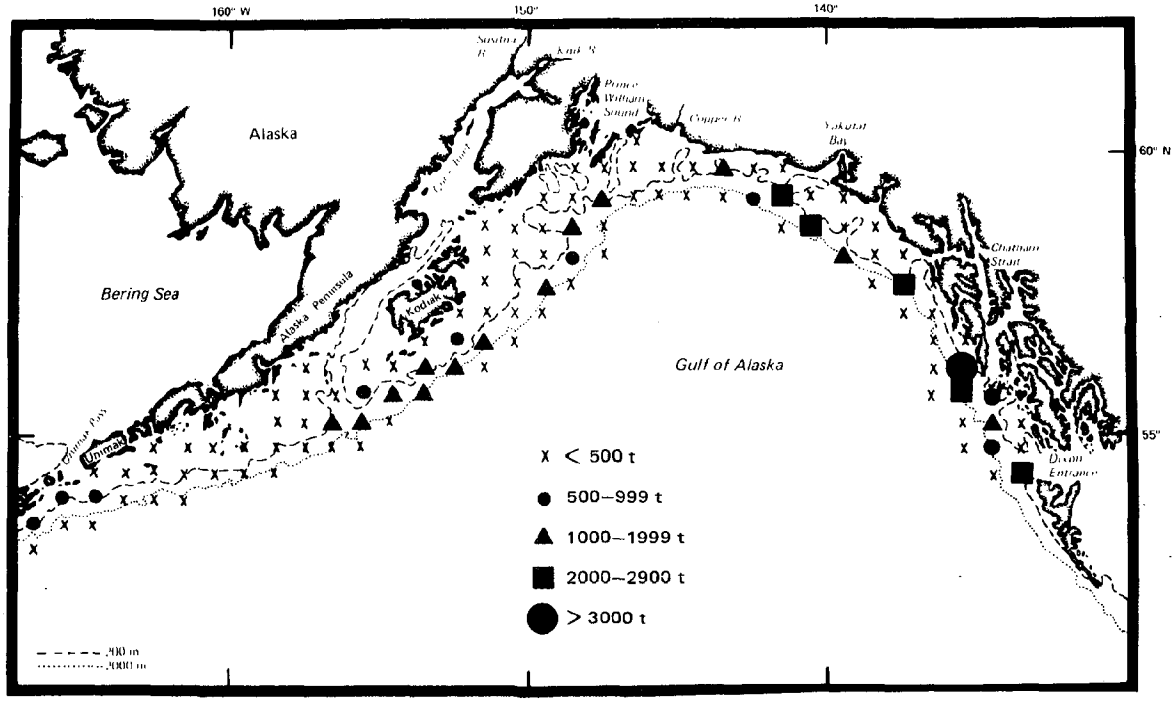


Figure 16.--Location and magnitude of Pacific ocean perch catches in the Gulf of Alaska by the Japanese trawl fishery. Catches are the average annual removals in 1963-75.

Since 1978 only stern trawlers (Figure 17) have been used in the trawl fisheries of the Gulf of Alaska. Many of these stern trawlers are 246 to 335 ft (75 to 102 m) in length and between 2,000 and 4,000 gross tons. All have freezing facilities and some have fish meal plants. A small number of trawlers are less than 500 gross tons. In 1978, USSR had 32 trawlers operating in the Gulf compared to 26 for Japan, 11 for ROK, and 5 for Poland (Table 5).

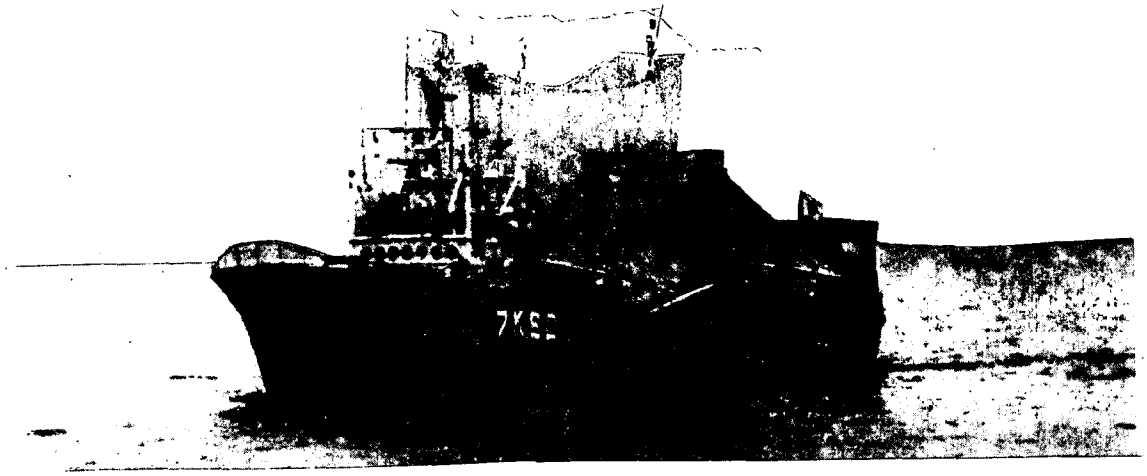


Figure 17.--Japanese stern trawler, Ryujin Maru No. 8, operating in the Gulf of Alaska. (Courtesy of U.S. Observer Program, NMFS, Seattle.)

Table 5.--Number and type of vessels in the foreign fisheries on Gulf of Alaska bottomfish in 1978.

Vessel type	Nation			
	Japan	USSR	ROK	Poland
Large stern trawlers[1/]	10	32	11	5
Medium size stern trawlers[2/]	16	--	--	--
Longline vessels	22	--	2	--
Transport vessels	26	7	4	--
Oil tankers	2	2	--	--

1/ Gross tonnage of 1,500 tons or more
2/ Gross tonnage of less than 1,500 tons

The foreign trawl fisheries of the Gulf of Alaska have undergone major changes since their beginnings in 1962. In the early and mid-1960's, Soviet and Japanese trawlers concentrated on rockfish, mainly Pacific ocean perch, and within a few years (1964-66) removed about 800 to 900 thousand t of rockfish from the Gulf. This excessive removal from a stock that in its prefishing condition constituted between 1.5 to 2.0 million t of fish (Quast 1972) brought about a sharp decline in abundance. Annual catches of rockfish reached almost 400 thousand t in 1965 and then fell to less than 100 thousand t in 1969. By 1973, the annual catch was less than 70 thousand t; in 1978 and 1979 it dropped to less than 12 thousand t because of catch restrictions (Figure 18). A comparison of the catch per unit of effort (CPUE), an indicator of stock density, from research surveys conducted in 1961 with that from research surveys of the early 1970's suggests as much as a 14-fold decrease in Pacific ocean perch density in some areas of the Gulf (Figure 19). The fall in CPUE in the Japanese fishery is a reflection of this decline in stock abundance (Figure 20).

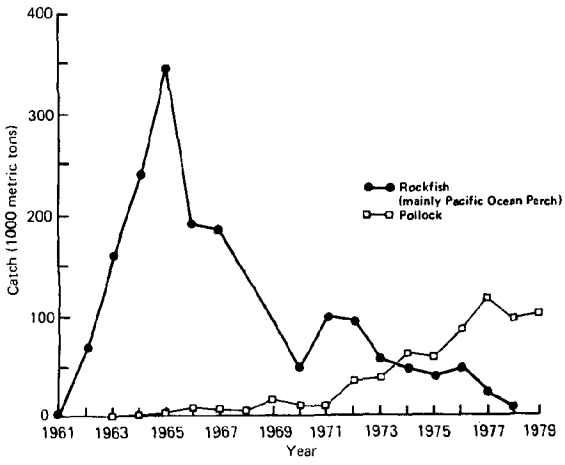
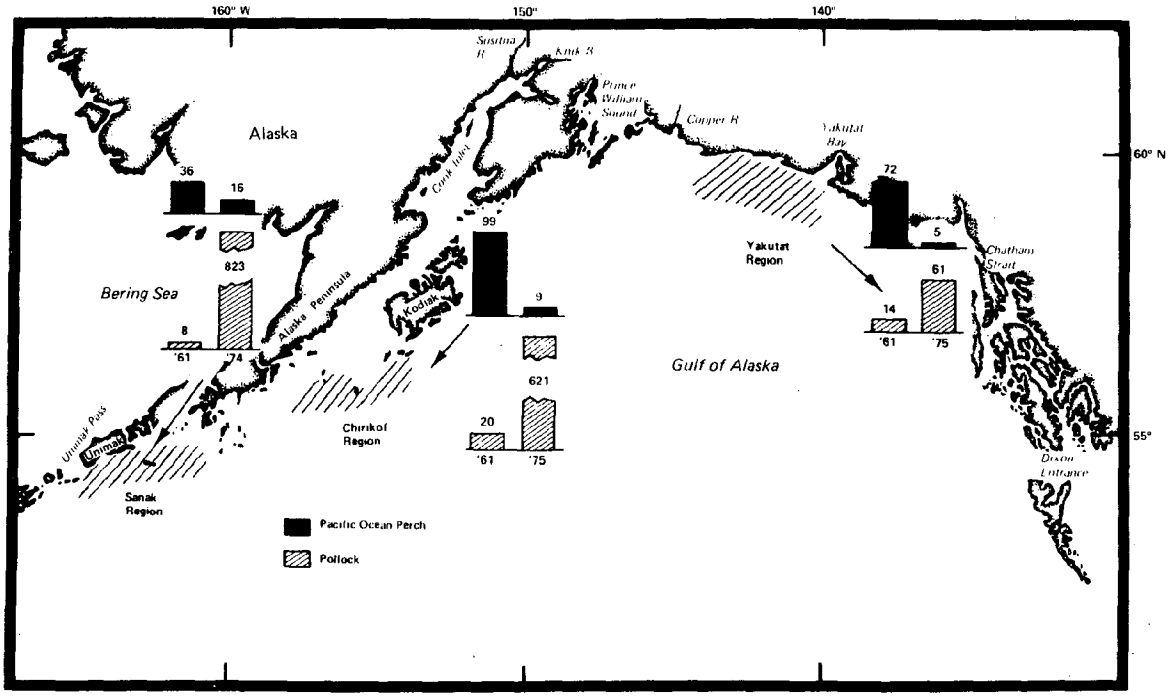


Figure 18.--Rise and decline in landings of Pacific ocean perch followed by increase in the importance of pollock in the foreign trawl fishery of the Gulf of Alaska.

With the decline of the Pacific ocean perch stock, foreign trawl fisheries increased their efforts to take walleye pollock and Atka mackerel. Annual pollock catches increased sharply from 9.5 thousand t in 1971 to 34.8 thousand t in 1972. By 1974, the catch of

Figure 19.--Changes in stock density of Pacific ocean perch and walleye pollock in the Gulf of Alaska as suggested from changes in survey catch rates (kg/hr) between 1961 and 1974-75.



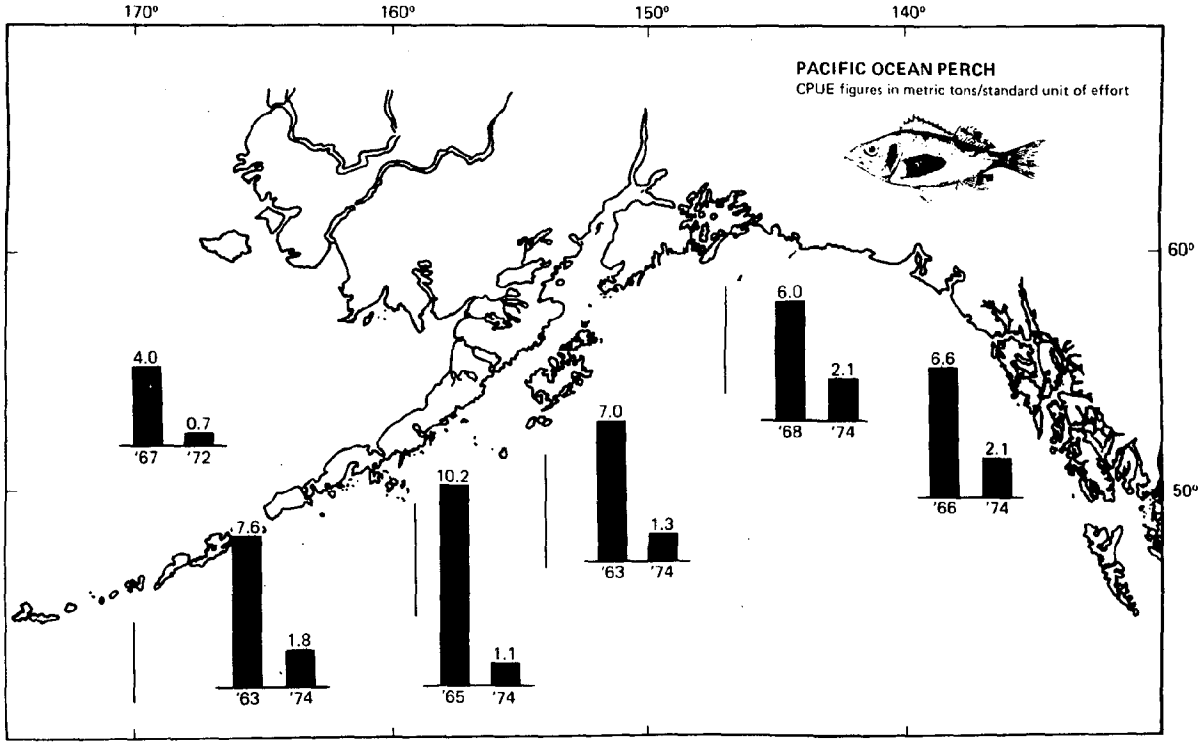


Figure 20.--Regional decline in the catch-per-unit of effort (CPUE) of Pacific ocean perch in the Japanese trawl fishery in Alaskan waters between the 1960's and early 1970's.

this species reached 61.9 thousand t; and with increased efforts by ROK trawlers on pollock in 1976, the catch rose to 86.5 thousand t and then to 120.4 thousand t in 1977 (Figure 18). Most of the pollock harvest has come from the western Gulf of Alaska (Figure 21), with Japan, USSR, and ROK the principal nations fishing this resource. The Soviet trawl fishery has also directed effort on Atka mackerel starting in 1979 when 7.3 thousand t were taken. The catch of Atka mackerel rose to 28.4 thousand t in 1975 but has since leveled off to 19 to 20 thousand t per year. Major fishing grounds for this species in the Gulf of Alaska are south of Kodiak Island and near the Shumagin Islands (Figure 22).

Most bottomfish stocks that are fished by the foreign trawl fisheries appear to be in good condition. Results of research surveys suggest that the pollock stock has increased substantially between the early 1960's and the 1970's (Figure 19). Potential yield of this stock is estimated to be about 166 thousand t per year, which the fisheries have yet to reach. In 1978 this potential yield or allowable catch has been allocated among the various foreign and U.S. fisheries. Atka mackerel is another important resource that is in a healthy state with no evidence of overfishing. Other species, such as cod and various species of flatfish and rockfish, that are taken in the foreign trawl fisheries have not been adversely affected by the fishing effort, but catch limitations have been established for these species and species groups to prevent overfishing.

Stocks of Pacific ocean perch and sablefish, however, are at low levels of abundance relative to earlier years. The allowable catch of these species has been set low to permit rebuilding of these resources (Table 4).

Setline Fishery

Since its inception in the Gulf of Alaska in 1963, the foreign setline fishery has concentrated on sablefish, a species which occurs throughout the northeastern Pacific and Bering Sea but has its center of abundance in Gulf of Alaska waters. As adults, sablefish prefer the slope region of the continental shelf where they are fished by the foreign fleets from bottom depths of 400 to 500 m and greater. The setline fishery captures sablefish that are between 50 and 85 cm in length.

In the slope region of the shelf, the setline fishery captures other species, particularly rattails, which at times can be a major component of the catch. Thornyheads[3/], along with flounders and other bottomfish, are also taken.

In 1978 the foreign setline fishery was allowed to conduct a directed fishery for Pacific cod but only in the region of the Gulf of Alaska west of long. 157° W. Then in 1979, the allowed fishing area was expanded from long. 157° W eastward to long. 140° W but only during the period

---

3/ Species of rockfish under the scientific name, Sebastolobus.

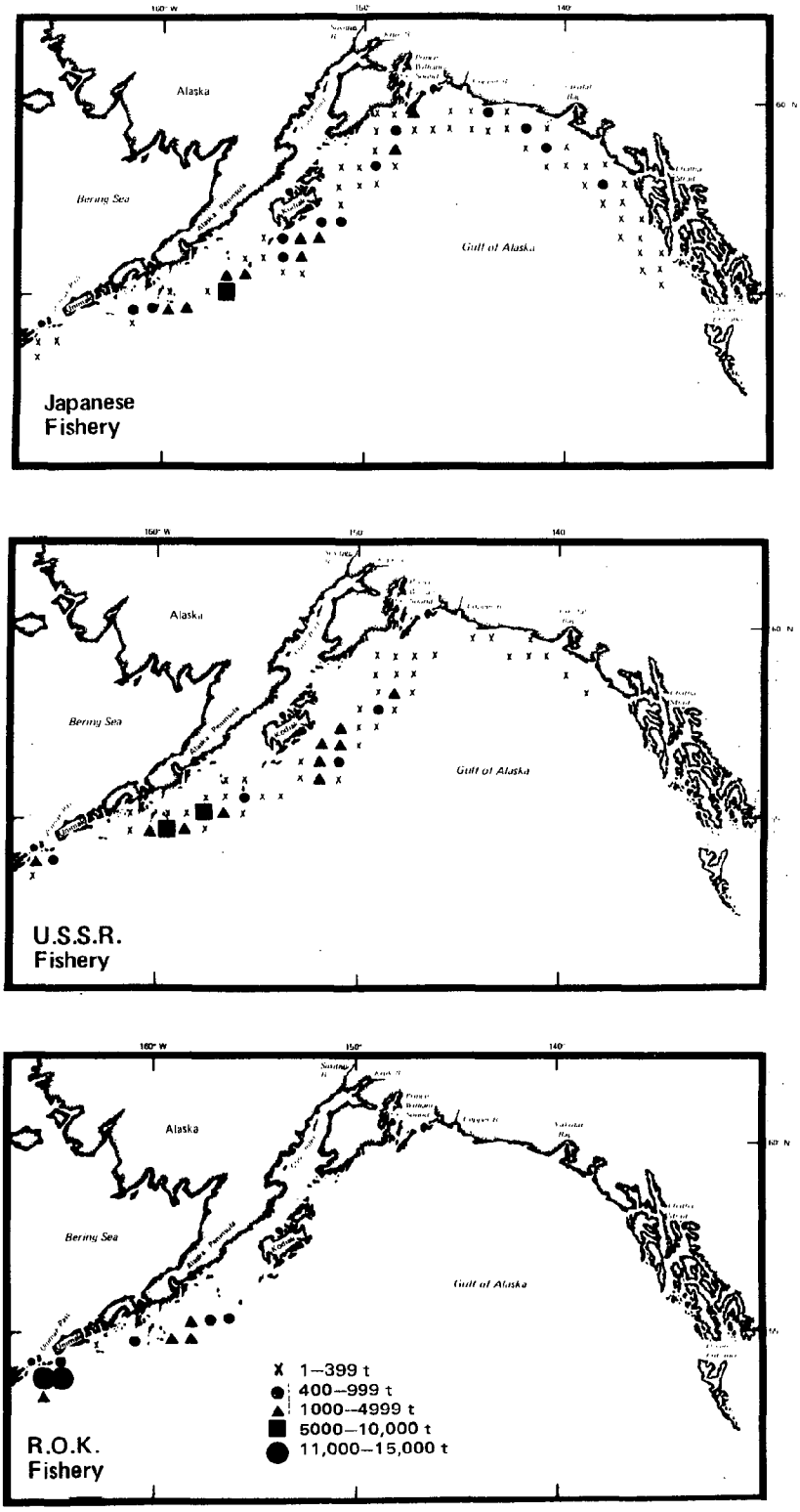


Figure 21.--Location and magnitude of the walleye pollock catch by the trawl fisheries of Japan, USSR, and ROK. Catches are annual removals in 1977.

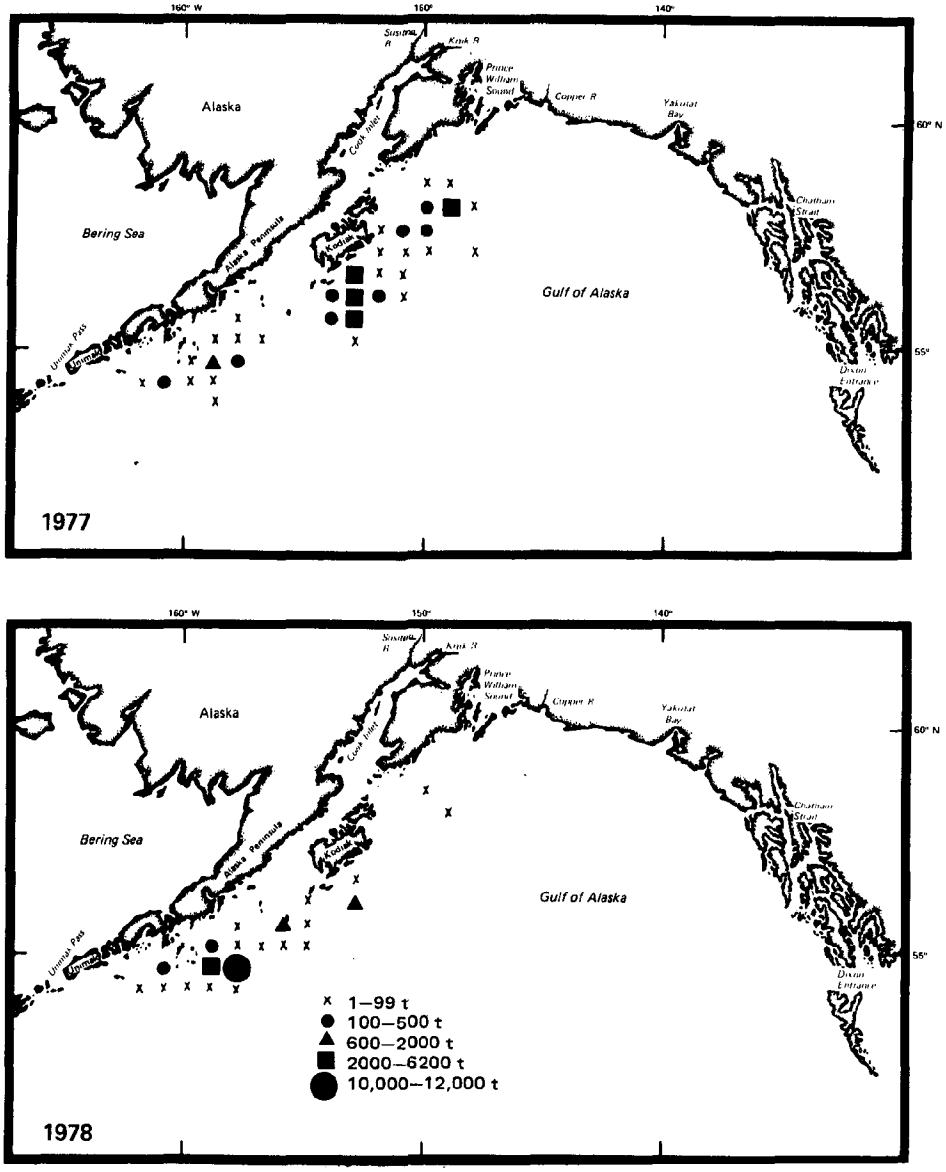


Figure 22.--Principal fishing locations of the USSR Atka mackerel fishery in the Gulf of Alaska, showing distribution of annual catch, 1977-78.

when no halibut fishery was occurring. The Japanese foreign setline fishery for cod in 1978 caught 5.4 thousand t, the Shumagin Islands region being the most productive area (Figure 23). Turbot, sculpins, and small amounts of other species were taken incidentally in this fishery.

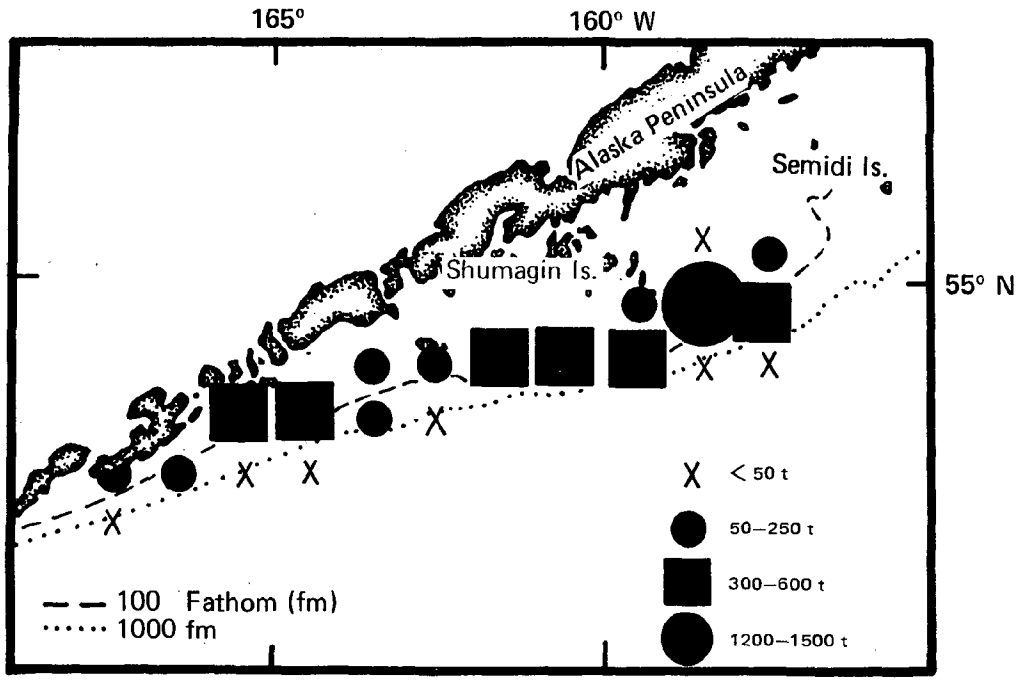


Figure 23.--Location of the Japanese longline fishery for Pacific cod in the Gulf of Alaska in 1978.

Historically, the Japanese were the first foreign nation to fish for sablefish in the Gulf of Alaska using setline gear. They began their operations in 1963 and were the sole foreign national in this fishery until 1972 when ROK fishermen began longlining for sablefish. When the Japanese began fishing for Gulf of Alaska sablefish, they attempted to use sunken or near bottom gillnets, but this method was abandoned for longline fishing which has remained, since 1964, their only mode of fishing.

The standard unit of Japanese longline gear is called the hachi and consists of a groundline 75 m in length with 36 to 38 regularly spaced gangions attached (Figure 24). At the end of each gangion is a hook which is baited, preferably with squid. A Japanese longline vessel sets a string of 390 to 420 hachis connected end to end along the sea bottom. This amounts to 29-30 km of groundline with approximately 15,000 hooks attached. It may take 2-1/2 hours to set the gear and 10 to 15 hours to recover it. Recovery begins after the gear is set and starts with the first hachi that was set. After landing a sablefish, it is headed, gutted, and frozen for shipment to Japan. A typical Japanese longline vessel is about 50 m long with a gross weight of 500 tons. ROK fishermen use a similar technique in longlining for sablefish. They also use a conical-shaped baited trap to capture sablefish (Figure 24). In 1978 in the Gulf of Alaska, the Japanese operated 22 longline vessels and the Koreans, 2 (Table 5).

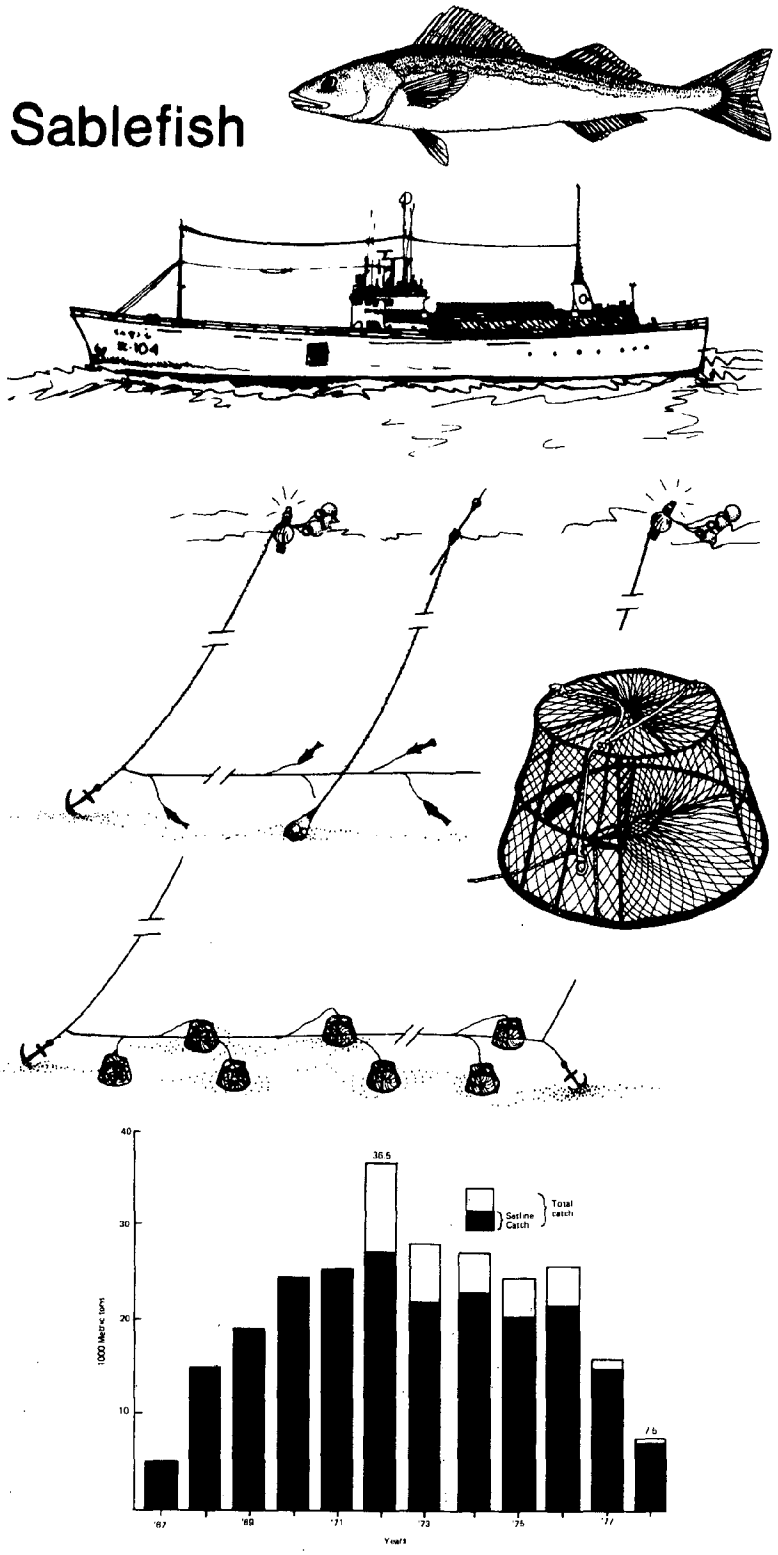


Figure 24.--Foreign catch of sablefish in the Gulf of Alaska (1967-78) and principal harvesting methods--longline and trap fishing.

In the initial year of the fishery, Japanese vessels harvested less than 2,000 t of sablefish, but the catch rose to about 15 thousand t in 1969. With the entry of ROK in the setline fishery in 1972, the total foreign setline catch reached its highest level of 27.3 thousand t. Fishing pressure from the setline fishery, and to some extent from the trawl fisheries in the 1970's, was apparently too much for the sablefish resource to bear. Decline in abundance may have been as much as 50% in the Japanese setline fishery as measured by catch for boat-day (Figure 25). In 1977 a catch limit of 19.5 thousand t was established through FCMA, and in 1978 this limit was further reduced to 8 thousand t as a means of rebuilding the stock to former levels. An additional restriction was imposed which prohibited the operation of a foreign setline fishery in the eastern Gulf of Alaska from Dixon Entrance northwest to the longitude of 140° W--a region that had been one of the most productive for the setline fishery in the past (Figure 26).

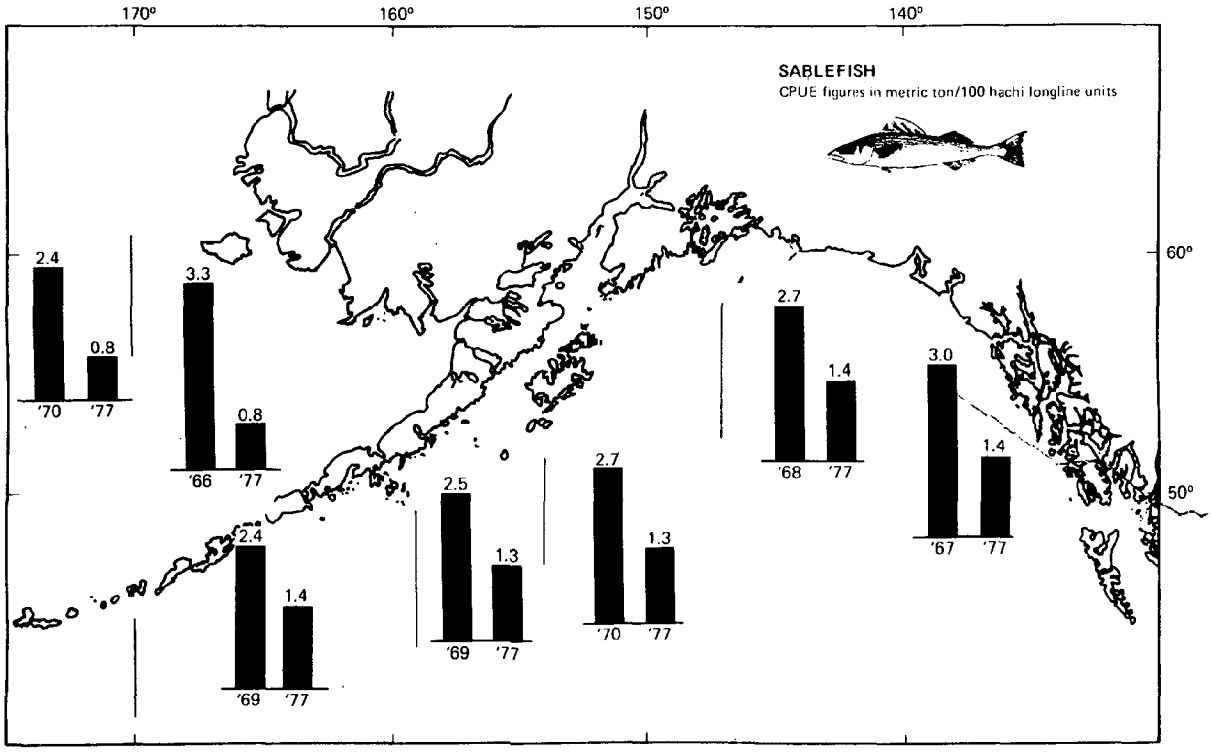


Figure 25.--Regional decline in the catch-per-unit of effort (CPUE) of sablefish in the Japanese longline fishery in Alaska waters.

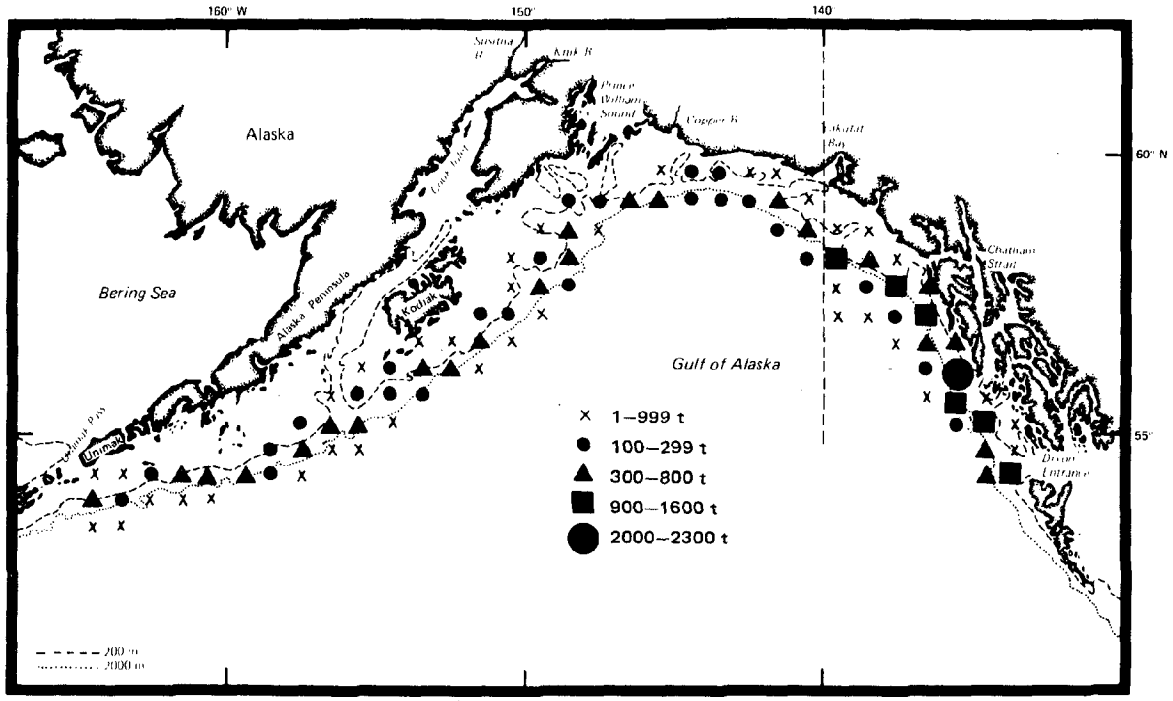


Figure 26.--Distribution of Japanese sablefish catches in the Gulf of Alaska in 1972, the year when the annual catch of the Japanese setline fishery peaked. In 1978, all foreign setline fisheries were prohibited from fishing east of long. 140° W in the Gulf of Alaska.

CHARACTERISTICS OF THE FISHERY RESOURCES

Life History

Commercial Crabs

Dungeness, king, and snow crabs are all very similar in their reproduction and growth. Mating occurs in the spring. For each species, the male grasps the female and waits until she sheds her old hard shell before mating. With king and snow crab, the male then spreads sperm over the female's pleopods while at the same time the female releases eggs which become attached to the appendages under her abdominal flap. This results in fertilization at the time of mating. In contrast, a Dungeness male places sperm in receptacles underneath the female's abdominal flap; fertilization is not immediate but takes place several months later when the female releases her eggs in the absence of the male.

With all the species, the mass of released eggs becomes attached to hair-like appendages under the abdomen of the female where development

proceeds until hatching and releasing of the young. In the case of Dungeness crab (the most fecund of the crab species), the egg mass may contain as many as 1.5 million eggs. King crab females may have from 50,000 to 400,000 eggs and snow crab from 20,000 to 140,000 eggs.

Hatching of the eggs occurs in the following spring. The larvae become planktonic and are subject to the movements of tidal and ocean currents. After 2 to 4 months, the actual duration depending upon the species of crab and water temperature, young crab settle to the sea bottom.

Growth of crabs is not a continuous process but occurs at brief intervals when the shell is soft after molting. The frequency of molting is high in young crabs but becomes less and less frequent as the crabs approach maturity. After maturity, male and female crabs molt no more than once a year and just prior to mating.

Rate of growth, age at maturity, and longevity vary among the crab species. Dungeness crab growth is quite rapid (Figure 27) with maturity being reached at age 2 or 3, but longevity is short (8 years) compared to king and snow crabs. King crab mature at age 6 or 7 and may live as long as 31 years. Maximum age for snow crab may be 12 years, and they mature at age 5 or 6 (David Somerton, personal communication[4/]). For all three crab species, males grow to a larger size than females.

Crabs feed on a variety of small bottom invertebrates and may on occasion attack and consume small fish. They are also scavengers and will readily feed on the remains of dead animals. In turn, crabs are preyed upon by large fish such as halibut, cod, and others. In some localities, the octopus can be an important predator of Dungeness crab.

Adults of king crab, Dungeness crab, and possibly snow crab have an annual onshore-offshore movement associated with breeding. In late winter, king crab move from deep water (200 to 300 m or greater) to depths less than 70 m where mating takes place. Breeding crabs will be found at shallow depths along the shore, in bays, and in submerged banks such as

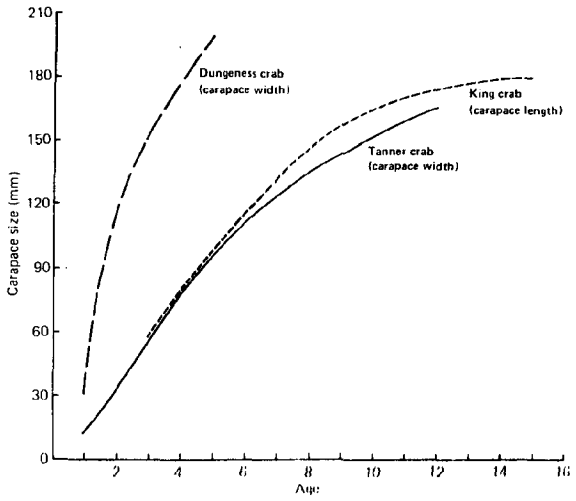


Figure 27.--Growth of male crabs--Dungeness, king, and Tanner. Data from Butler (1961) for Dungeness crab, McCaughran and Powell (1977) for king crab (Paralithodes camtschatica), and Somerton and Low (1977) for Tanner crab (Chionoecetes bairdi).

4/ Personal communication from David Somerton, Department of Quantitative Sciences, University of Washington, Seattle, WA.

Marmot Flats and Portlock Bank near Kodiak Island. Following maturity, king crab return to deep water where they feed throughout the summer, fall, and early winter (McMullen 1967). Dungeness crab also have a seasonal depth movement but the range of depths is not as great as king crab. The majority of Dungeness crab reside at depths less than 70 m so that most movements are confined to this zone. Crabs move to shallow depths in the spring for breeding and then return to deeper water where they stay for the remainder of the year. There is no evidence of an onshore-offshore movement for snow crab in the Gulf of Alaska, but bathymetric shifts in population have been reported for other species of snow crab (Pereyra 1966; Yoshida 1941).

Shrimp

The life histories of commercial shrimp of the Gulf of Alaska are all similar so that a treatment of one species, pink shrimp, should be representative of the group. The remarkable feature of pink shrimp and its congeners is that they are males in their first years of life, metamorphose to females, and function as females for the remainder of their lives.

Reproduction takes place each year in the fall, and, like the crabs mentioned above, the male deposits sperm on the underside of the female. As the eggs are extruded, they are fertilized and become attached to hairs on the abdominal segments. Large females may produce 2,000 or more eggs. The eggs are carried by the female until hatching takes place the following spring. The released larvae are planktonic for about 3 months after which they assume the semidemersal habit of the adults. Most growth is completed in the first 4 years of life when the shrimp may reach 11 to 18 cm in length. Longevity is 5 or 6 years.

Pink shrimp are scavengers and predators. They prey on zooplankton as well as small animals on the sea bottom. Many kinds of animals feed on shrimp. Important predators among fish are cod, halibut, turbot, pollock, and flathead sole.

Seasonal movements have not been observed for Gulf of Alaska pink shrimp, but pink shrimp in the Gulf of Maine are known to have an inshore-offshore movement (Clark & Anthony 1977).

Bottomfish

Bottomfish reproduce in various ways, the most common of which is the release of pelagic eggs by the female and their simultaneous fertilization by the male. This is true for most flatfish, including halibut, and for cod, pollock, and sablefish. The free-floating eggs develop in the plankton; after a period of 1 or 2 weeks, the eggs hatch and planktonic larvae emerge. Duration of larval development varies among species--a few weeks in some species and almost a year in others such as the Dover sole.

Other bottomfish (most sculpins, Atka mackerel, and greenlings) lay demersal eggs. An aberrant among flatfish, the rock sole is also a demersal egg

layer. In this mode of reproduction, the female will release eggs which are then fertilized by the male. The adhesive eggs attach themselves in a mass to rocks and other surfaces on the sea bottom. Development of the eggs and their hatching takes place on the seabottom. The larvae are planktonic.

A third method of reproduction is that of rockfish of the genus Sebastes. Males and females of a species pair up during one season of the year when internal fertilization occurs. Development of the eggs takes place within the female, and after several months, the young emerge and become dispersed in the plankton. With Pacific ocean perch, copulation occurs in the fall with release of the young in the following spring.

The fourth type of reproduction is found among the Gulf of Alaska thornyheads, a rockfish group of only two species. The female releases a mass of eggs that are held together by a gelatinous material. The gelatinous mass then rises to surface waters where it becomes free-floating (Pearcy 1962). Whether fertilization takes place within the female or at the moment when the eggs are extruded is not known.

The number of eggs released at spawning varies by species and, within a species, increases with the size of the female (Figure 28). Cod, followed by halibut, are the most fecund of the bottomfish--large females of these species can spawn over a million eggs. In contrast, the average fecundity of Atka mackerel may be only 9,000 eggs (Macy et al. 1978).

Spawning is seasonal and, for many bottomfish including halibut, cod, sablefish, and pollock, occurs during the winter-spring period. There are exceptions such as the Atka mackerel and Irish lords (sculpins of the genus Hemilepidotus) whose spawning seasons extend from late spring to early fall.

Individual growth varies considerably among the commercially important bottomfish. Pacific ocean perch is one of the slower growing species. It is long-lived and may be only 30 cm in length by age 10 and weigh slightly less than 0.5 kg. Halibut, by contrast, reach the largest size of any bottomfish in the northeastern Pacific. Its growth is relatively slow during

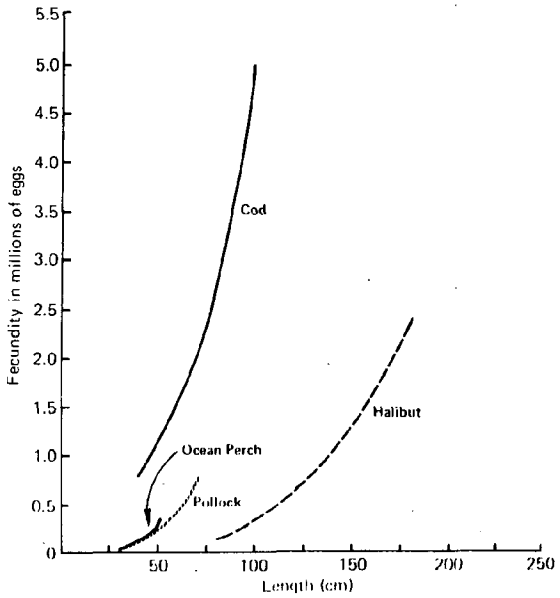


Figure 28.--Increase in fecundity with length of fish for commercially important bottomfish. Data from Ketchen (1961) for Pacific cod, Schmitt and Skud (1978) for Pacific halibut, Gunderson (1977) for Pacific ocean perch, and Shew (1978) for walleye pollock.

its first 2 to 3 years of life; thereafter, growth is rapid, and by age 10, a halibut may be 110 cm in length and weigh about 20 kg (Figure 29). Cod, followed by sablefish, are also rapidly growing fish. Among bottomfish, females reach a greater size than males, contrary to that found in crabs.

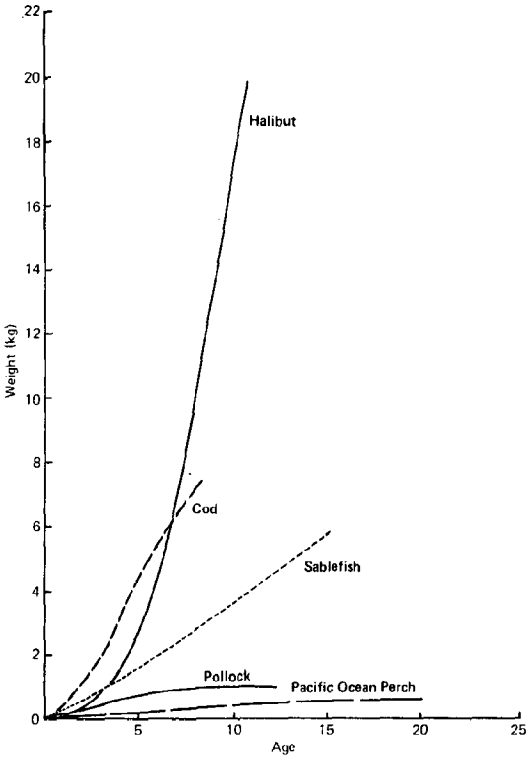


Figure 29.--Growth of Pacific halibut and other important bottomfish of the Gulf of Alaska.

Little is known about the movements of bottomfish. Seasonal mass migrations covering great distances are conjectural. There is, however, evidence of seasonal inshore-offshore movements for several of the species. Adult fish move from deep water to shallow depths in the spring where they remain throughout the summer. In the fall, there is a return to deep water. The depths covered by these movements vary by species. In addition to seasonal movements, there may be vertical movements in the water column associated with time of day. This has been observed for pollock. The adults of this species are found in aggregations near the sea bottom during daylight hours. By late afternoon, these aggregations begin to rise and, by evening, are dispersed in near surface waters. The following morning, they return to the sea bottom. This is a typical pattern for some species and is associated with feeding, where foraging may be more intense during the evening and early morning hours than at other times of the day. These daily vertical movements may not always take place, and occurrence may be a function of light conditions, behavior of prey, season, or other environmental variable.

There are also movements related to the age of fish. The young of many species, particularly those of flatfish, are found on the bottom of bays, inlets, and other nearshore areas where they grow and develop. As they approach maturity, they move into deeper water to join the adults. Pollock and sablefish young are found in near surface waters rather than on the bottom and may be found in great numbers in straits and nearshore areas. By the time they reach first maturity, they may have joined the adult portion of the population in bottom waters of the outer continental shelf. Thus, for many of the bottomfish, the young develop separately from the adults and enter the adult population at or near maturity from shallower depths.

Bottomfish prey on a variety of organisms which may include semidemersal- and pelagic-occurring forms, as well as animals that live on or near the sea bottom. Halibut, cod, and to some degree turbot are apex predators in the demersal animal community. Adults of these species prey on a variety of medium to large fish such as pollock, flatfish, and sculpins. They also feed on crab, shrimp, and small prey such as smelt and krill.

Those bottomfish which are semidemersal (walleye pollock, Atka mackerel, and Pacific ocean perch and other rockfish) feed predominantly on small to medium size nektonic prey such as large amphipods and copepods, krill, smelt, and other small fish. At times pollock are cannibalistic. Sablefish is probably the most omnivorous of the bottomfish, roaming from near bottom to mid-depths of the slope region of the shelf and feeding on semipelagic animals such as squid and lantern fish as well as bottom-dwelling fish and invertebrates. It is also a scavenger and will consume refuse and the remains of animals. From the little that is known of the feeding habits of rattails, it is believed that they too are omnivorous.

The strictly benthic feeders among the bottomfish are various species of flatfish, sculpins, eelpouts, and other less known fish groups. Among the commercially important flatfish, the soles (Dover, rex, and rock) seek out and consume small invertebrates (worms, snails, clams, brittlestars, etc.) that crawl on or burrow into the seabed. Small crustaceans that swim close to the seabed may also fall prey to these soles. Flathead sole is also a bottom feeder but will feed on small nektonic animals such as shrimp, krill, herring, and smelt when the opportunity arises.

Marine mammals are the main consumers of bottomfish. Fur seals are known to feed on walleye pollock and Atka mackerel. Sea lions will also prey on walleye pollock and attack Pacific halibut and other flounders. Baleen whales (e.g., blue and humpback whales) that swallow large patches of aggregated prey probably engulf at times schooling bottomfish, such as pollock. Sperm whales may also feed on bottomfish.

Birds take an unknown quantity of bottomfish, mainly pelagic juveniles of bottomfish species.

Mortality from natural causes (i.e., predation, disease, starvation, stress) varies considerably among the bottomfish species. Pacific halibut has one of the lowest natural mortality rates, allowing individuals of this species to sometimes live to a very old age. In contrast, walleye pollock, Pacific cod, and Atka mackerel have a much higher natural mortality. To appreciate these differences in natural mortality, survivorship curves are given in Figure 30 for Pacific halibut, rock sole, and walleye pollock. These curves are based on an overall average natural mortality rate for fish, age 3 and above, and hence do not show the variations in mortality by age that is the general rule. If mortality from fishing were also considered, then the survivorship curves would be steeper than shown in Figure 30.

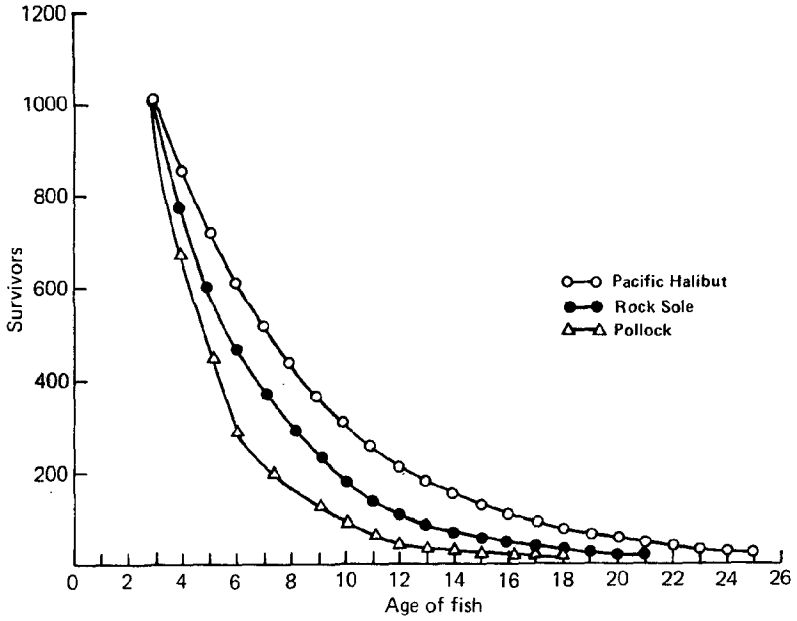


Figure 30.--Estimated decline in a year class of Pacific halibut, rock sole, and walleye pollock from age 3 and above because of natural mortality. This is a generalized view for species comparison and assumes a constant annual rate of mortality.

Distribution of Resources

The depth distribution of bottomfish and shellfish shows several features. For a given species, depths of common occurrence and abundance of the adults remain fairly similar throughout its geographical range. Some variations occur because of seasonal bathymetric movements and changes in bottom type, but, in general, each species appears to be confined to certain bottom depths. Examples of depth ranges for some of the principal Gulf of Alaska bottomfish and shellfish are given in Figure 31. This is a generalized scheme for the Kodiak Island area and is based on resource survey results and fisheries information.

Besides showing the depth specificity of each species, Figure 31 also shows the separation by depth of species or species groups having strong phylogenetic ties. Thus, among the snow crabs, there is essentially a shelf-occurring species (Chionoecetes bairdi) and the slope-dwelling species

(C. tanneri and C. angulatus). Among rockfish, members of the genus Sebastes are confined to the upper slope and shelf depths, whereas species of Sebastolobus extend their depth range into the lower slope region. Similarly, among the gadids, cod is found at shallow depths, pollock at intermediate depths, and rattails in deep water. This depth replacement of species and species groups having similar evolutionary origins is not unique to bottomfish and crab but may be found in other animals of the sea and has its parallel among land animals where replacement is in relation to land elevation.

A third feature associated with depth distribution is that the deeper occurring species or groups tend to have a greater geographical distribution than those in shallow water. The geographical range of the slope species (Dover sole, rex sole, turbot, Pacific ocean perch, sablefish, and rattails), for example, extends from the Bering Sea south to California. Many of the shallow water or shelf species (king crab, certain species of snow crab, Atka mackerel, yellowfin sole, and pink shrimp), however, are confined principally to Alaskan waters.

From similarities in depth distribution, life history, and other characteristics, seven faunal groups can be distinguished among the bottomfish and shellfish of the Gulf of Alaska: 1) pandalid shrimp; 2) shelf crab, rock sole, and sculpins; 3) cod and flounders; 4) walleye pollock and flathead sole; 5) Dover and rex sole; 6) rockfish; and 7) a bathyal or lower slope group. A description of these groups follows.

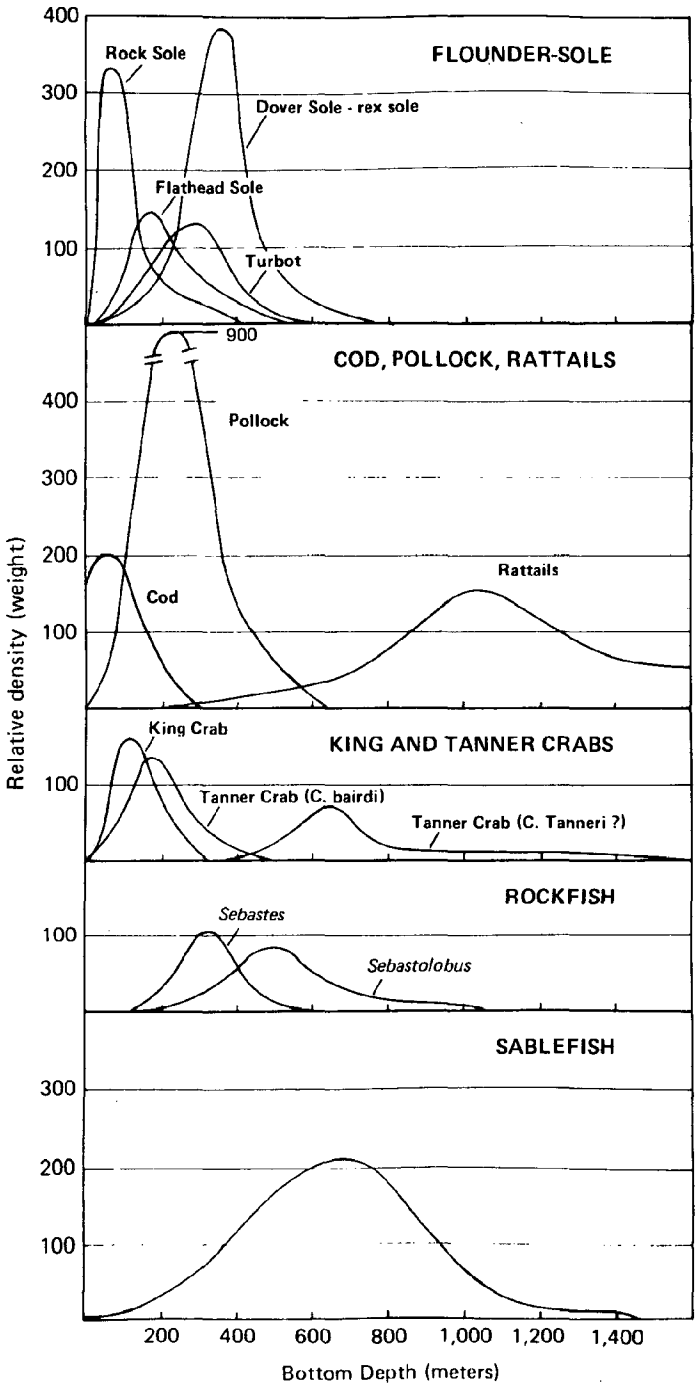


Figure 31.--Generalized scheme of the relative density with depth of the principal bottomfish and crabs occurring on the continental shelf and slope south of Kodiak Island. Distribution is of the adults of these species during the summer.

Pandalid Shrimp

Shrimp aggregations, predominantly of pink shrimp (Pandalus borealis), are found over mud bottom in the region of the outer continental shelf and in submarine canyons that bisect the shelf. Some of the most productive shrimp fishing grounds in Alaska are found where these canyons extend shoreward into deep water bays. An example of such grounds is that located on the south side of Kodiak Island near Twoheaded Island.

It is in the Kodiak region and westward that the more productive fishing areas are found. In the eastern Gulf, shrimp abundance declines; and in west coast waters, pink shrimp, Pandalus borealis, is replaced by the similarly appearing P. jordani.

Shelf Crab, Rock Sole, and Sculpins

This group consists of king crab, snow crab (C. bairdi), rock sole, and sculpins and occupies bottom depths of the shelf although, during the winter, portions of their populations may be found in deeper water along the upper part of the shelf's slope. These animals obtain all or most of their sustenance from feeding on benthic animals. They also appear to have a common reproductive strategy. Rather than releasing their eggs into a pelagic environment like most other important demersal species, they either retain their eggs until hatching (king and snow crab) or release a mass of eggs which adhere to the sea bottom where hatching takes place (rock sole and sculpins). Thus, for these bottomfish and crabs, development and hatching of the eggs occur in the bottom environment of the shelf.

Closely akin to this shelf group is Atka mackerel. Although Atka mackerel is not strictly a bottom-dwelling animal, it lays demersal eggs on the sea bottom, as does rock sole and sculpins. During the winter, Atka mackerel is found aggregated near the shelf's edge off Kodiak Island (Figure 32) and westward.

Species of the shelf group are most dense and abundant in the western Gulf of Alaska as indicated from the fisheries on crab (Figure 7) and Atka mackerel (Figure 7) and from bottomfish surveys (Figure 33). King crab are not found south of British Columbia and off the west coast of the United States, and other species (C. bairdi, rock sole, and Atka mackerel) become insignificant in the shelf fauna.

Cod and Flounders

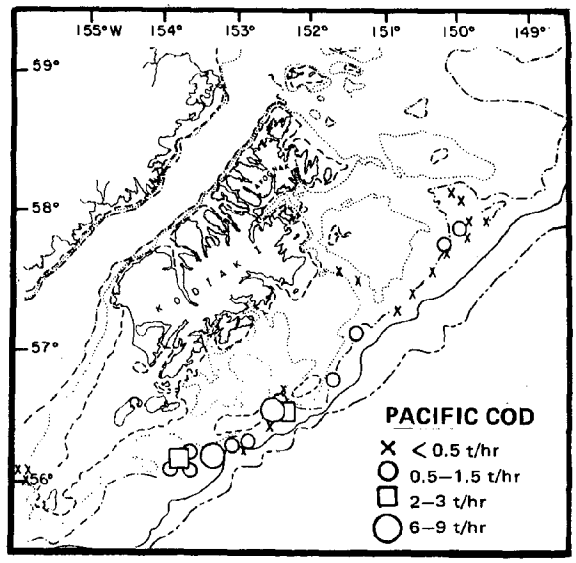
This group consists of Pacific cod and the large flounders, Pacific halibut and arrowtooth flounder. They are all apex predators within the demersal animal communities of the northeastern North Pacific and Bering Sea and feed on a variety of prey and prey sizes. In regions where adults of

these species are abundant, they are found from shallow to deep water and in a variety of habitats.

In Alaskan waters, Pacific cod is most dense in the western Gulf of Alaska (Figure 34), where large schools may be encountered at various depths depending upon the season of the year. During the winter and spring, cod appear to be most abundant in the canyons that cut across the shelf and along the shelf's edge and upper slope 100-400 m (Figure 32). By late summer, they have shifted to shallower depths. During winter and spring, productive cod areas are located near Albatross Bank south of Kodiak Island and near Sanak Island west of the Shumagin Islands Large trawl catches of cod have also been taken in the deeper portions of bays along the Alaska Peninsula and around Kodiak Island.

Pacific halibut is relatively abundant throughout the shelf and upper slope region of the Gulf of Alaska. Some of the most productive fishing grounds are found from the Yakutat region to Kodiak Island (Figure 14).

Turbot is abundant over a depth range similar to that of Pacific halibut (100-500 m). During the winter months, turbot aggregate in the deeper portion of this range. Highest density of turbot, as indicated from trawl surveys, has been found in waters off southeastern Alaska (Figure 34).



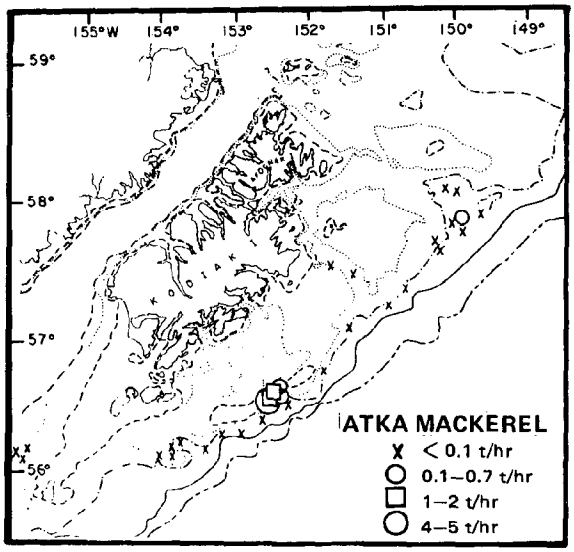


Figure 32.--Availability of Pacific cod and Atka mackerel during NMFS 1978 winter trawling survey in the Kodiak Island region, using the NOAA research vessel Miller Freeman.

Pollock and Flathead Sole

These species are generally associated with areas of soft bottom at depths of 100 to 600 m, which include the submarine canyons that cut across the shelf in various areas, outer shelf depths, and the upper slope. Within this depth zone, there is a seasonal depth oscillation from shallow to deep in the fall and a return to shallow waters in the spring. Another common

feature shared by these species is opportunistic feeding in which they can shift from a diet of benthic animals to that of free-swimming off-bottom animals.

Walleye pollock is apparently the dominant animal in the demersal fish community of the shelf and upper slope of the western Gulf of Alaska as well as the eastern Bering Sea (Figure 35). Density and abundance decline in the eastern Gulf of Alaska, but there is a slight resurgence in abundance in the inside and outside waters of southeastern Alaska and British Columbia. Farther south off Washington, Oregon, and California, pollock becomes of little significance in terms of abundance and is replaced by the ecologically similar Pacific whiting in the fish community.

Flathead sole is one of the more important flatfish of the Gulf. Relative density is high in the western and northeastern part of the Gulf of Alaska and in the inside waters of southeastern Alaska (Figure 35). In the coastal waters of Washington, Oregon, and California, abundance of flathead sole is very low.

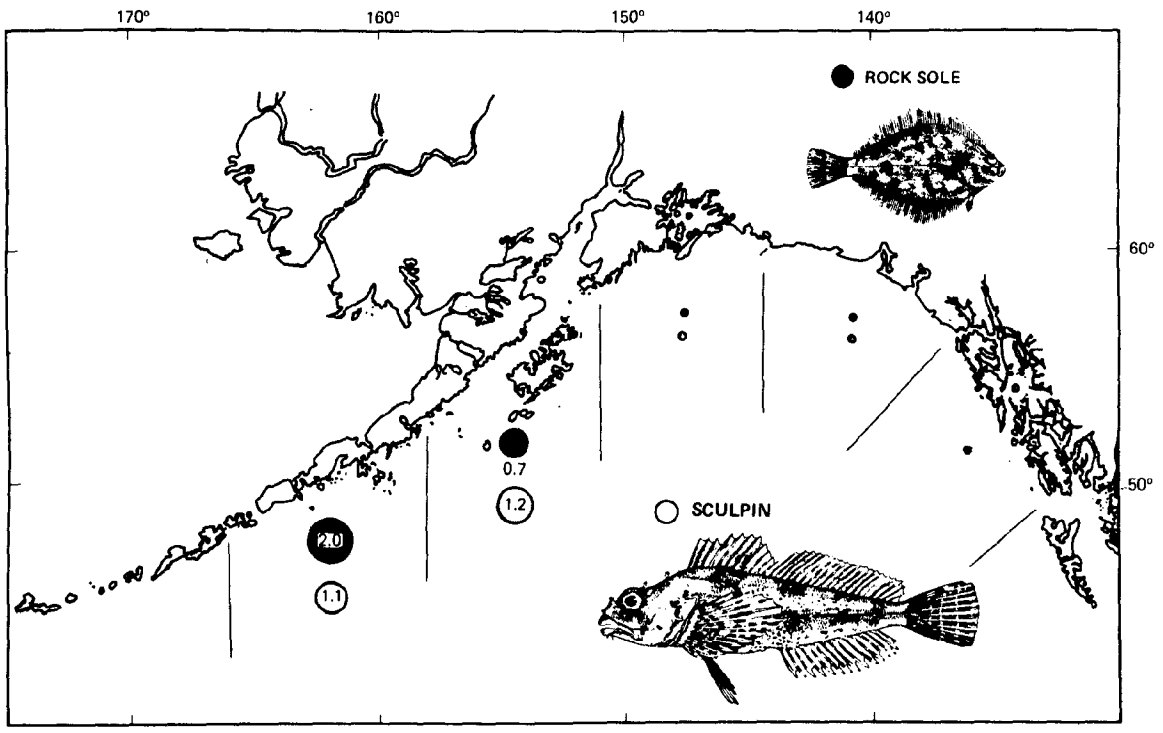


Figure 33.--Apparent density (t/km^2) of rock sole and sculpins in various regions of the Gulf of Alaska based on NMFS bottom trawl surveys (1973-76) at depths of 400 m and less.

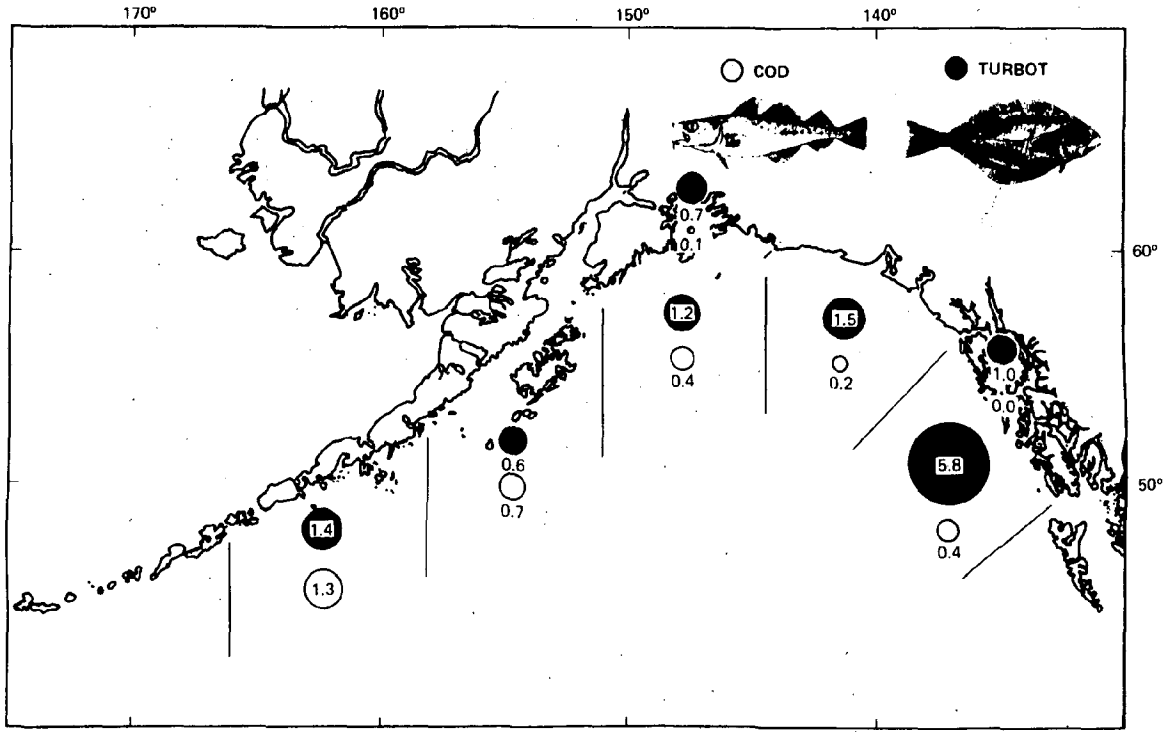


Figure 34.--Apparent density (t/km^2) of Pacific cod and turbot in various regions of the Gulf of Alaska based on NMFS bottom trawl surveys (1973-78) at depths of 400 m and less.

Dover Sole and Rex Sole

Both species are closely associated with the soft bottom community of benthic animals that occurs in the deep water portions of submarine canyons that cut across the shelf and along the upper part of the shelf's slope. Dover and rex sole are especially adapted to feeding on small detrital-consuming invertebrates that live within the sediment (polychaete worms, clams) or on or near the surface of the bottom (amphipods and other small crustaceans, shrimp, and brittlestars). These soles have small mouths. When they are handled, a great amount of mucous, which may be a defense reaction, is exuded.

Dover and rex soles are found throughout the northeastern Pacific and in the Bering Sea and are abundant in Oregon and California waters. The magnitude of the Gulf of Alaska stocks is unknown.

Rockfish (Sebastes) Group

At the shelf's edge, and particularly along the upper slope of the shelf (300-500 m), lie concentrations of the rockfish (Sebastes) group. This rockfish complex is characteristic of the demersal fish community at these depths from California waters to the Gulf of Alaska and the Bering Sea. Pacific ocean perch is a major component of this group. In any region of the Gulf of Alaska, there may be 20 or more rockfish species occurring at the shelf's edge and upper slope. With these species, fertilization of the eggs and embryonic development are internal. Seasons of copulation and larval release, however, vary by species. Rockfish move on and off the sea bottom and occur in schools. Many species of this group feed on small to medium size prey which they capture off the bottom or at middepths.

At one time before intensification by the foreign fisheries in the 1960's, Pacific ocean perch, together with other rockfish species, dominated the demersal fish community of the outer shelf and slope in the Gulf of

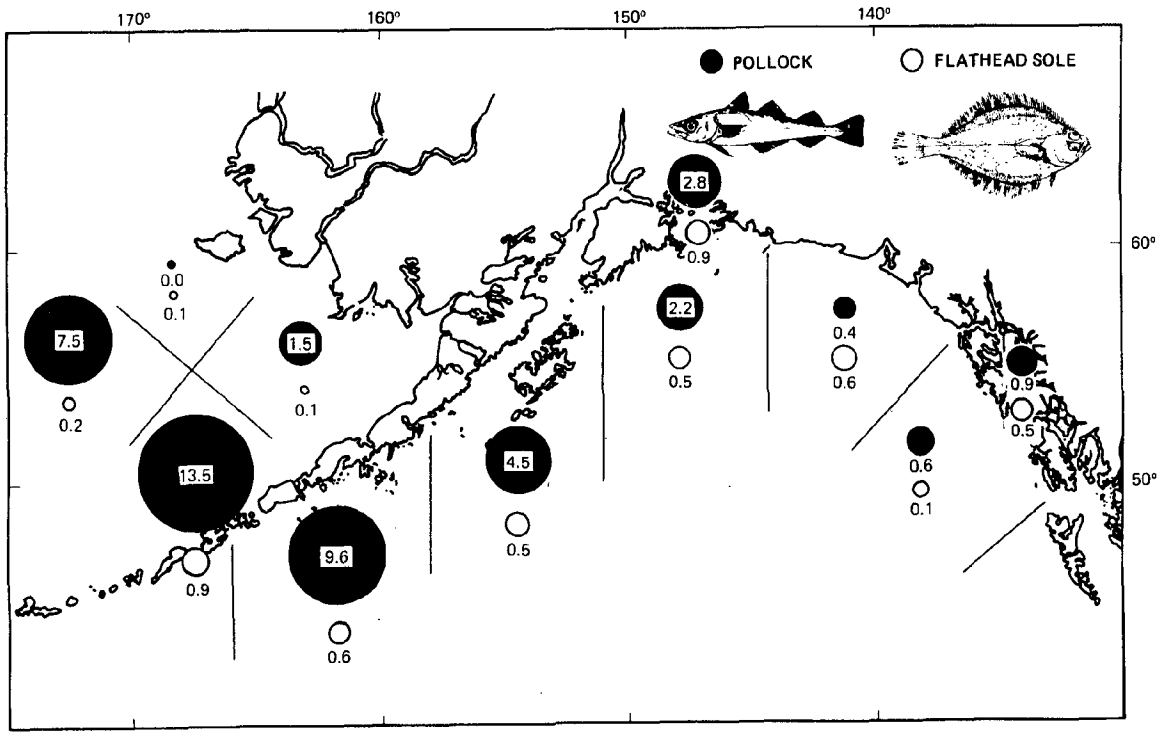


Figure 35.--Apparent density (t/km^2) of walleye pollock and flathead sole in various regions of the Gulf of Alaska and eastern Bering Sea as suggested from NMFS bottom trawl surveys (1973-78) at depths of 400 m and less.

Alaska. Now, Pacific ocean perch abundance is low and catch restrictions are in effect to rebuild this resource. Catch rates from the Japanese trawl fisheries before and after fishing intensification in the mid-1960's reflect the marked change in Pacific ocean perch abundance (Figure 19).

Bathyal Group

Important species and species groups in the bathyal or slope region (400-1200 m) of the Gulf of Alaska are sablefish, rockfish of the genus Sebastolobus, rattails, and snow crab (Figure 31). Adult sablefish occur over a wide range of depths that includes the outer shelf, slope, and abyssal region. The center of abundance by depth of adult sablefish appears to lie at 400-1000 m.

As is typical of many of the species and species groups that reside at bathyal depths, sablefish are found throughout a wide area--from Baja California in the south, to the Bering Sea in the north, and in waters off Japan to the west. Greatest abundance is in the Gulf of Alaska, particularly in the eastern Gulf of Alaska, where the highest annual catches have been taken. Tagging studies suggest that most adult sablefish do not migrate any great distance, although there have been cases where individual fish, tagged and released in west coast waters, have been recovered later in the Bering Sea (Wespestad et al. 1978). It would appear that most sablefish remain in the same general bottom area where they settled after their pelagic existence as juveniles. There is some evidence that, as sablefish age, there is a tendency for them to move into deeper water so that during research surveys the proportion of young fish in the catches decreases with increasing depth and the proportion of older fish increases (Alton 1972).

Rockfish of the genus Sebastolobus are characteristic animals of the bathyal region throughout the northeastern Pacific and in the Bering Sea. There are two species, S. altivelis and S. alascanus, the latter of which is more abundant and is commonly called the shortspined thornyhead. It is taken with some frequency in the Japanese longline fishery for sablefish and cod and is part of the bycatch of foreign trawlers concentrating on pollock and Pacific ocean perch in Gulf of Alaska waters.

Rattails are composed of a number of species, of which Chalinura pectoralis and Coryphaenoides acroleipis may be the most abundant. Both species have been frequently encountered in large numbers during deep water trawl surveys in west coast waters (Alton 1972; Day and Pearcy 1968) and in the Bering Sea, Aleutians, and Sea of Okhotsk (Novikov 1970). Novikov has reported on several occasions trawl catches of Chalinura pectoralis amounting to 4 to 6 t. Another abundant rattail in the Bering Sea is C. Cinereus. Rattails are an important component in the Japanese longline fishery for sablefish in the slope region and may at times be a greater proportion of the total catch than sablefish. Like sablefish, rattails are generalized feeders, consuming a variety of benthic and semipelagic prey.

Another species or species group that characterizes the slope fauna is the deep water snow crabs. Little is known about their distribution and abundance in Alaskan waters. Off the west coast of the United States, Chionoecetes tanneri is abundant in the slope region and has been taken during deep water trap surveys of sablefish in the eastern Gulf of Alaska. The extent of its distribution and abundance in the western Gulf of Alaska is not known although a similarly appearing snow crab, C. angulatus, is found in the slope region of the western Gulf of Alaska.

Distribution of bathyal fauna, characterized by sablefish, Sebastolobus spp, rattails, and snow crab, extends to the seamounts that dot the abyssal plain of the Gulf of Alaska. During seamount studies by the National Marine Fisheries Service in 1979, all four species or groups were found to be a dominant and common component of deep water trap catches (Pruter 1979).

ACKNOWLEDGMENTS

The author thanks Marion Hanson of the Resource Assessment and Conservation Engineering Division of the Northwest and Alaska Fisheries Center, Seattle, for her editing and formatting assistance and Carol Hastings and Nancy Williams-Nelson of the Center's Graphics Unit for their preparation of the figures given in this report.

REFERENCES

ALASKA DEPARTMENT OF FISH AND GAME
1979. Westward region shellfish report to the Alaska Board of Fisheries, April. Unpubl. rep., Alaska Dep. Fish Game, Div. Commer. Fish., Westward Reg. Off., Kodiak, AK 99615, 254 p.

ALTON, M.S.
1972. Characteristics of the demersal fish fauna inhabiting the outer continental shelf and slope off the northern Oregon coast. In A.T. Pruter and D.L. Alverson (editors), The Columbia River estuary and adjacent ocean waters, p. 583-634. Univ. Wash. Press, Seattle and London.

BUTLER, T.H.
1961. Growth and age determination of the Pacific edible crab, Cancer magister, Dana. J. Fish. Res. Board Can. 18:873-891.

CLARK, S., and V.C. ANTHONY
1977. An assessment of the northern shrimp resource of the Gulf of Maine. MS Rep. 77-06. Northeast Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Woods Hole, MA 02543, 7 p.

COBB, J.N.
1906. The commercial fisheries of Alaska in 1905, p. 5-46. U.S. Dep. of Commer. and Labor, Bur. of Fish., Doc. No. 618.
1916. Pacific cod fisheries. Rep. U.S. Comm. Fish. 1915, append. 4, (Doc. 830), 111 p.
1927. Pacific cod fisheries. Rep. U.S. Comm. Fish. 1926, append. 7:385-499. (Doc. 1014)

DAY, D.S., and W.G. PEARCY.
1968. Species associations of benthic fishes on the continental shelf and slope off Oregon. J. Fish. Res. Board Can. 25:2665-2675.

ELDRIDGE, P.
1972. The weathervane scallop fishery. In D.H. Rosenberg (editor). A review of the oceanography and renewable resources of the northern Gulf of Alaska, p. 339-350. Univ. Alaska, Fairbanks, Inst. Mar. Sci., Sea Grant Rep. 72-23.

GUNDERSON, D.R.
1977. Population biology of Pacific ocean perch, Sebastes alutus, stocks in the Washington-Queen Charlotte Sound region, and their response to fishing. Fish. Bull., U.S., 75:369-403.

KETCHEN, K.S.
1961. Observations on the ecology of the Pacific cod (Gadus macrocephalus) in Canadian waters. J. Fish. Res. Board Can. 18:513-558.

MACY, P.T., J.M. WALL, N.D. LAMPSAKIS, and J.E. MASON.
1978. Resources of non-salmonid pelagic fishes of the Gulf of Alaska and eastern Bering Sea. Parts 1 and 2. Unpubl. manuscr. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112, 356 p. and 358 p.

McCAUGHRAN, D.A., and G.C. POWELL.
1977. Growth model for Alaska king crab (Paralithodes camtschatica). J. Fish. Res. Board Can. 34:989-995.

McMULLEN, J.C.
1967. Breeding king crabs Paralithodes camtschatica located in ocean environment. J. Fish. Res. Board Can. 24:2627-2628.

NICKERSON, R.B.
1975. A critical analysis of some razor clam (Siliqua patula Dixon) populations in Alaska. Alaska Dep. Fish Game, 294 p.

NOVIKOV, N.P.
1970. Biologiya maloglazogo dolgokhvosta Chalinura pectoralis v severnoi chasti tikhogo okeana (Biology of Chalinura pectoralis in the North Pacific). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72):300-326. In Russian. (Transl. by Israel Program Sci. Transl., 1972, p. 304-331 in P.A. Moiseev (editor), Soviet fisheries investigations in the northeastern Pacific, Part 5, avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT 71-50127.

PEARCY, W.G.
1962. Egg masses and early developmental stages of the scorpaenid fish, Sebastolobus. J. Fish. Res. Board Canada, 19:1169-1173.
1978. Distribution and abundance of small flatfishes and other demersal fishes in a region of diverse sediments and bathymetry off Oregon. Fish. Bull., U.S. 76:629-640.

PEREYRA, W.T.
1966. The bathymetric and seasonal distribution and reproduction of adult Tanner crabs, Chionoecetes tanneri Rathbun (Brachyura: Majidae), off the northern Oregon coast. Deep Sea Res. 13:1185-1205.

PRUTER, A.T.
1979. Gulf of Alaska seamount survey. Northwest and Alaska Fish. Cent., Mo. Rep., November, p. 1-7. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

QUAST, J.C.
1972. Reduction in stocks of the Pacific ocean perch, an important demersal fish off Alaska. Trans. Am. Fish. Soc. 101:64-74.

RONHOLT, L.L., H.H. SHIPPEN, and E.S. BROWN.
1978. Demersal fish and shellfish resources of the Gulf of Alaska from Cape Spencer to Unimak Pass, 1948-1976 (a historical review), Volumes 1-4. Processed Rep., various pagination. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

SALMON INDUSTRIES OF THE UNITED STATES.
1974. The Pacific salmon - a unique problem in ocean resource management. Unpubl. rep. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112, 34 p.

SCHMITT, C.C., and B.E. SKUD.
1978. Relation of fecundity to long-term changes in growth, abundance, and recruitment. Int. Pac. Halibut Comm., Sci. Rep. 66, 31 p.

SHEW, D.M.
1978. Pollock fecundity study; preliminary report. Unpubl. manuscr. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112, 42 p.

SOMERTON, D., and L.L. LOW.
1977. Determination of minimum size and yield limitations for Tanner crabs in the eastern Bering Sea. Processed Rep. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112, 49 p.

WALL, J., R. FRENCH, and R. NELSON, Jr.
1978. Observations of foreign fishing fleets in the Gulf of Alaska, 1978. Unpubl. manuscr. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112, 60 p.

WESPESTAD, V.G., K. THORSON, and S. MIZROCH.
1978. Movement of sablefish (Anoplopoma fimbria) in the northeastern Pacific ocean as determined by tagging experiments (1971-1977). Processed Rep. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112, 54 p. + append.

YOSHIDA, H.
1941. Hokusen inyo kanirui no seishyoku ni tsuite (On the reproduction of useful crabs in northern Korea). (2). Suisan Kenkyushi: 36(7):116-123. In Japanese. (Partial transl. (Chionoecetes opilio, p. 116-121) by H.C. Kim, 1963. Avail. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112, 14 p.)

Metric and English Equivalents

Centimeters to Inches (1 cm = 0.394 in)		Meters to Feet (1 m - 3.28 ft)		Meters to Fathoms (1 m - 0.546 fm)		Kilograms to Pounds (1 kg - 2.205 lb)		Metric Tons to Pounds (1 mt - 2204.6 lb)	
cm	in	m	ft	m	fm	kg	lb	mt	lb
10	3.9	5	16	50	27	1	2.2	50	110,230
20	8.2	10	33	100	55	5	11.0	100	220,460
30	12.2	20	66	200	109	10	22.0	200	440,920
40	16.3	50	164	500	273	15	33.1	500	1,102,300
50	20.4	100	328	1000	546	20	44.1	1000	2,204,600